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CHROMOSOME BEHAVIOR AT MEIOSIS IN TRIPLOID TRADESCANTIA HYBRIDS

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(WITH TWELVE FIGURES)

INTRODUCTION

A recent study of the chromosomes at the first post-meiotic mitosis in the microspores of diploid species of *Tradescantia* L. has demonstrated the rather frequent occurrence, especially in hybrids, of spontaneous chromosome changes (Giles 1940). A similar examination of the chromosomes of triploid *Tradescantia* hybrids has shown the same types of post-meiotic changes. It has also been found that other types of aberrations, resulting from meiotic irregularities, occur at the pollen grain mitosis. To aid in interpreting and distinguishing these two classes of aberrations, a study has been made of chromosome behavior at meiosis. The actual types of aberrations revealed at the first post-meiotic mitosis will be described and discussed in the second part of this study (Giles 1941). The present observations at meiosis have also provided material for an analysis of the comparative amounts of structural hybridity of the chromosomes in the diploid and tetraploid parents and in the triploid hybrids between them, and this paper deals in large part with a discussion of this subject. Since it has recently been shown that heterozygous inversions may occur with considerable frequency in species of *Tradescantia* (Sax 1937; Darlington 1937a; Swanson 1940), particular attention has been paid to evidence for inversion hybridity.

MATERIALS AND METHODS

The triploid plants used in this investigation were the result of a cross between a diploid *Tradescantia paludosa* Anders. and Woods. as female, and a tetraploid *T. canaliculata* Raf. as male parent. The *T. paludosa* stock was originally obtained by Dr. Edgar Anderson at Gentilly, Louisiana, some years ago, and a clone from this material is maintained at the Harvard Biological Laboratories. The *T. canaliculata* was collected by the writer near Atlanta, Georgia, in the spring of 1938. The two parents are quite typical of their respective species, and show no evidence of having hybridized with

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other species in the field. In their external characteristics the hybrids give almost no indication of being intermediate between the two parents. It is true that the parental species do not differ greatly to begin with, but even of those characters in which they are different, such as the distribution of stomata, shape and size of bracts and leaves, general habit of plant, and hairiness of leaves (particularly the lower leaf sheaths, and entire young leaves), the hybrids tend to exhibit almost all the characters of *T. canaliculata*. This is very probably due to the presence in the hybrids of two sets of genes from *T. canaliculata* and only one from *T. paludosa*. It is interesting to note that hybridization under natural conditions involving these two species and *T. hirsutiflora* Bush, with the occasional production of triploids, has been reported recently by Riley (1939).

In the cytological study of the plants, aceto-carmine smears of meiosis were used.

CHROMOSOME BEHAVIOR AT MEIOSIS

A comparative study has been made of chromosome behavior at meiosis in the three types of plants studied, with particular emphasis on the various types of aberrations due to structural hybridity. Of these, inversion bridges are by far the commonest, and their frequencies in the parental types and the hybrids were found to differ considerably. The types of chromosomal configurations in the three groups and their relation to chiasma frequency and inversion bridge frequency have also been considered.

Pairing Relations and Chromosome Distribution. Meiosis in the diploid *T. paludosa* is very regular. The only irregularity in pairing noted was the occurrence of 4.3 per cent univalents at metaphase. Despite the presence of a certain number of univalents, chromosome distribution is very regular, for in 128 cells scored only 6–6 distributions were noted. Also in the same cells no lagging chromosomes were noted (table 1). The chiasma frequency is fairly high, 2.4 per bivalent, of which one-third are interstitial.

Meiosis in autotetraploid tradescantias is characterized by the occurrence of quadrivalents and trivalents as well as bivalents and univalents. In the plant of *T. canaliculata* studied, the frequency of quadrivalents was 2.7 per cell and of bivalents, 5.1 per cell (table 1). This is somewhat lower than usual, for in most tetraploid tradescantias studied the frequency of quadrivalents per cell has been at least three (Darlington 1929; Anderson and Sax 1936). This lower percentage of quadrivalents may be due to the somewhat lower chiasma frequency, 0.7 per chromosome, as compared with 0.8 and 0.9 for plants with more quadrivalents. The increased percentage of bivalents may mean that the chromosome complement was derived from two gametes quite unlike in the structure of their chromosomes. If the resemblances as to pairing properties of chromosomes were closer within

each set than between the two sets, we should expect a higher proportion of bivalents. That a situation with similar results may indeed arise has been shown recently by Skirm (1940). He found that doubling the chromosome number of a hybrid *Tradescantia* resulted in a tetraploid with an extremely low frequency of quadrivalents. Here the four chromosomes sets present existed as two identical sets which apparently differed sufficiently from one another to condition synapsis almost exclusively as bivalents. In distribution the chiasmata studied in the present plant agreed with findings for other autotetraploid tradescantias in being almost all (99.3 per cent) terminal. The distribution of chromosomes was rather irregular because of variations in quadrivalent and trivalent orientation and the random passage of univalents to the poles. Also the amount of lagging was rather high. Of 263 cells counted, lagging chromosomes were present in 58, or 22.1 per cent.

Meiosis in the triploid hybrids was much more irregular than in either of the two parental plants. Five plants were studied in detail and the data (averages) on chiasma frequency and types of configurations in these are

TABLE 1

Pairing configurations and chiasma frequencies in diploid T. paludosa, tetraploid T. canaliculata, and triploid hybrids.

Plant	Number of cells	I	II	III	IV (Also V & VI in 3n's)	7 configurations in one cell (3n)	Total Xta	Xta per chromosome	Terminal Xta per cent	Interstitial Xta per cent
T. paludosa (2n)	30	8	176	.....	.....	.....	440	1.2	66.4	33.6
	per cell:	.27	5.87	.....	.....	.....	14.7			
T. canaliculata (4n)	85	97	435	47	233	.....	1532	.75	99.3	.7
	per cell:	1.1	5.1	.5	2.7	.....	18.0			
3n hybrids (averages for 5 plants)	307	678	712	1104	26	13	4053	.73	90.1	9.9
	per cell:	2.2	2.3	3.6	.....	.....	13.1			

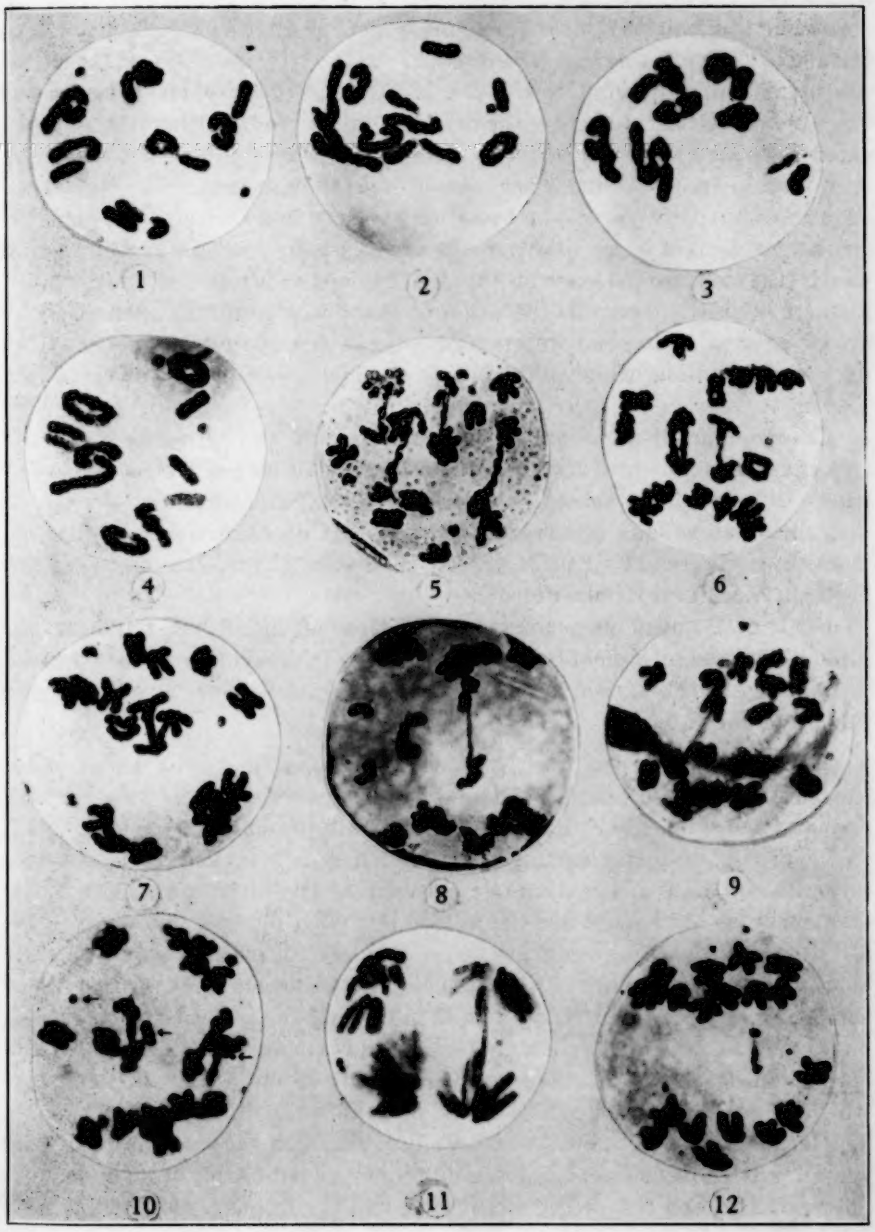
presented in table 1. The plants did not vary much in the relative number of univalents, bivalents, and trivalents per cell, or in their chiasma frequency. The average number of trivalents for the five was 3.6 per cell. This is considerably less than that found in an autotriploid plant of *T. bracteata* Small with a frequency of 4.64 (Sax 1937), and is evidently related to the hybrid nature of these plants, since they have two sets of *T. canalic-*

ulata chromosomes and only one of *T. paludosa*. That all the chromosomes are largely homologous is shown by the observation of a number of cells with six trivalents (fig. 1).

Of particular interest in obtaining an estimate of the amount and nature of structural hybridity in these plants are the observations on unusual pairing configurations at metaphase. Such configurations were encountered only in the triploids, but this is to be expected as a result of the modified method of pairing due to the presence of an extra set of chromosomes, as well as to their hybrid origin. Failure to observe them in the diploid and tetraploid does not prove the absence of the types of hybridity which they indicate. The observed configurations indicate the presence of translocations between, or duplications in, non-homologous chromosomes, and duplication in different arms of the same chromosome. It is not possible in these plants to distinguish between translocations and duplications since the observed configurations might result from either condition. The types of synapsis which indicate translocations and duplication are multivalents and a total of more than six distinct configurations in one cell (fig. 2). The majority of the multivalents are quadrivalents (fig. 3), but occasional associations of five and six chromosomes have been observed. The presence of more than six configurations in a cell indicates intra-haploid pairing and shows that homologous segments are present in non-homologous chromosomes. These two types of irregularties in pairing have been observed in approximately 12.5 per cent of the sporocytes examined. The evidence for

Explanation of figures 1–12

Configurations observed at metaphase and anaphase of meiosis in the triploid hybrids. ×660. FIG. 1. Cell containing six trivalents at metaphase. FIG. 2. Metaphase with seven paired configurations, indicating intra-haploid pairing; two univalents also present. FIG. 3. Quadrivalent pairing at metaphase (lower left). FIG. 4. Metaphase showing ring of three with interstitial chiasma (left center), indicating duplicated segments in differing arms of the same chromosome. FIG. 5. Four inversion bridges in the same cell at anaphase I. Centric and acentric fragments present. FIG. 6. Bivalent with inversion bridge in each arm (to left); small acentric fragments out of focus. Also single bridge and acentric fragment to right. FIG. 7. Two bridges connecting all three chromosomes of a trivalent at anaphase. One acentric fragment in middle of cell at right; two centric fragments at opposite poles to left. FIG. 8. At left center, univalent bridge resulting from precocious division of centromere at anaphase I; acentric fragment out of focus directly above bridge. Also single bridge at right center, and dividing univalent at left. FIG. 9. At lower right, loop chromatid and acentric fragment resulting from single crossing-over within an inversion. Precocious division of the centromere of such a chromosome would give a univalent bridge as seen in figure 8. FIG. 10. Three inversion bridges having acentric fragments (indicated by arrows) all of different lengths. The small one on the right is apparently attached to the end of a free arm. Three centric fragments are also present. FIG. 11. Single bridge in cell at right at anaphase II, resulting from a loop chromatid at anaphase I as seen in fig. 9. The acentric fragment present in the spindle was evidently included in the nucleus at anaphase I. FIG. 12. Bridge and acentric fragment resulting from inversion crossing-over in one of the small centric chromosomes often present in *Tradescantia*.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duplications in different arms of the same chromosome is obtained from the occasional observation of configurations typical of secondary trisomics (Belling 1927). Two of these which were noted occasionally are rings of three and univalents paired back on themselves. In the rings of three, one chiasma was usually interstitial, indicating the probable interstitial position of the duplicated segment (fig. 4). These two configurations are quite rare, and have been found in only about 2.5 per cent of the cells examined.

The comparative rarity of these unusual configurations shows that the structural changes which they indicate are relatively few and probably quite small. It is only the presence of unpaired regions as a result of the extra set in the triploid that permits detection of them. The resulting configurations are of interest in an interpretation of some of the aberrations noted at the microspore division, which will be discussed in the second part of this study (op. cit.).

Chromosome distribution at first anaphase in the triploids was quite irregular, as is indicated by a study of 158 cells (in two different plants) of which 107 (67.7 per cent) contained lagging chromosomes. Precocious division of univalents occurred commonly, but no misdivision of the centromere, as observed by Upcott (1937a) in *Tulipa* L. and Darlington (1939, 1940) in *Fritillaria* L., was noted.

Centric fragment chromosomes were present in all the triploids, the diploid, and the tetraploid. Particularly in the triploids, they were observed to pair with the larger chromosomes, indicating their homology with certain of these.

Heterozygous Inversions. The frequency, types, and behavior of inversion bridges at both anaphases I and II were studied in the two parental forms and in six of the F_1 hybrids. The data are presented in tables 2 and 3. In the diploid only single bridges were noted at A I (in 5.7 per cent of the cells). About half of the dicentric chromatids are without visible acentric fragments, as has been noted before for inversion bridges in *Tradescantia*. Most of the visible fragments are approximately spherical; that is, they are about as long as the width of a meiotic chromosome arm. However, occasional smaller or larger fragments are noted, indicating the presence of more than one inversion. Since all centromeres are approximately median, individual chromosomes cannot be distinguished, and it is impossible to determine whether the different inversions are in the same or in different chromosomes. The latter is quite probably the case, since, although the chiasma frequency is high, no double bridges involving either one or both arms of a single chromosome have been observed. In the tetraploid the frequency of bridges on a cell basis was 18.5 per cent. Six cells of 281, or 2.1 per cent, had bridges in two different chromosomes. Here again approximately half the bridges were without fragments. In those cells where fragments were present these were

TABLE 2

Bridges at anaphase I of meiosis in diploid, tetraploid, and triploids.

Plant	Number of cells	Number of cells with different numbers of bridges & percentage					Total number of bridges	Per cent bridges
		0	1	2	3	4		
T. paludosa (2n)	335	316 94.3	19 5.7	.....	.....	.....	19	5.7
T. canaliculata (4n)	281	235 83.6	40 14.3	6 2.1	.....	.....	52	18.5
3n hybrids (average per cent for 6 plants)	1015	646 64.7	308 30.8	52 3.65	8 .73	1 .15	492	40.9

TABLE 3

Bridges at anaphase II of meiosis in diploid, tetraploid, and triploids.

Plant	Number of cells (not tetrads)	Number of cells with different numbers of bridges & percentages				Total number of bridges	Per cent bridges
		0	1	2	3		
T. paludosa (2n)	194	190 97.9	4 2.1	.....	.....	4	2.1
T. canaliculata (4n)	300	290 96.7	9 3.0	1 .35	.....	11	3.7
3n hybrids (average per cent for 6 plants)	1494	1368 91.1	120 8.5	6 .4	.....	132	9.3

almost all small, only one as long as the width of a chromosome arm being noted. This seems to indicate that most of the inversions (at least those in which crossing-over occurs) are close to the ends of the arms. The frequency of bridges observed is much higher than any hitherto recorded in tetraploid tradescantias. Darlington (1937a) states, without giving specific examples or figures, that bridges occur in less than one per cent of the cells of tetraploid tradescantias and are less frequent than in diploids. It is possible that the higher percentage found in the present plant may be related to the higher frequency of bivalent pairing, although it seems more likely that such pairing would reduce the bridge frequency since regular pairing in small inversions would presumably not be facilitated. Bridges at anaphase II were noted in 3.7 per cent of the cells studied (7.4 per cent of the tetrads).

The frequency of bridges in six plants of the hybrid triploid population

varied somewhat. However, the plants were all alike in having a considerably greater frequency of bridges per cell than either of the parents. The higher frequency holds for both first and second anaphase, and is reflected in the much greater percentage of cells with more than one bridge. As many as four bridges in different chromosomes were observed in a single cell (fig. 5). Certain configurations also show that two inversions may be present in the same homologous chromosome. These may be in the same arm or in different arms. If crossing-over occurs in two heterozygous inversions located in opposite arms of a paired bivalent, the configuration shown in figure 6 will result. Similar behavior involving a trivalent instead of a bivalent results in a V-shaped association (fig. 7). The latter type has been observed several times. When two separate inversions are located in the same arm, complementary crossing-over in both of these results in unequal bridges with two acentric fragments of different lengths. Such a figure has been observed only once. The other possible types resulting from reciprocal and disparate crossing-over in the two inversions—respectively a single bridge plus an acentric ring and acentric fragment, and a single bridge and acentric fragment plus a very long free chromatid arm—have not been noted. These same types could also be produced by crossing-over in overlapping inversions (cf. Swanson 1940). One cell with two bridges of equal length in the same arm and equal acentric fragments was found. This condition is due to double crossing-over within a single inversion. The rarity of such configurations is due both to the low chiasma frequency in the triploids and the probable short length of most of the inversions. The frequency of bridges at anaphase II in the triploids is also rather variable and shows no constant relation in individual plants to the frequency at first anaphase. As has been pointed out by Upcott (1937b) this is due to the peculiar chromosome behavior of triploids. Of the four factors cited in her paper as important in triploid tulips, two seem to be of particular import in triploid tradescantias: non-disjunction, and precocious division of univalents. The passage of both centromeres of a dicentric chromatid to the same pole at first anaphase may give rise to a bridge at the second division, or if the separation is parallel the dicentric will be recovered in the microspore. Of the total of 430 dicentric bridges observed in the five triploids studied, 30 (7.0 per cent) were passing to the same pole. The precocious splitting of unoriented univalents which have undergone inversion crossing-over results in the occurrence of univalent bridges (fig. 8). Such behavior increases the frequency of bridges at the first division, but since they can be recognized an idea of their frequency can be obtained. In a count from plant 1, of a total of 80 bridges of all types, 7 (8.7 per cent) were univalent bridges. This seems to indicate that the frequency of non-disjunction and univalent bridges is about the same. However, no adequate records were kept for other plants, and it is possible that the fre-

quency of univalent bridges is too high in the sample cited. Most of the bridges at the second division are due to crossing-over within and proximal (disparate) to an inversion. These are evident as loops attached to one centromere at one pole at first anaphase (fig. 9) and are observed quite often.

The visible acentric fragments in the triploid vary a great deal in size, giving further evidence for the presence of numerous different inversions. Figure 10 shows three bridges, all having fragments of different sizes. These fragments rather often appear to be attached to the free arm of a chromatid at anaphase (fig. 10) as has been found in *Zea* L. (McClintock 1938) and consequently may be included in the nucleus at telophase I. Their inclusion is further indicated by the presence of occasional cells with fragments in the spindle at anaphase II (fig. 11). That only very few of these are ever included in the nucleus at telophase II will be shown later (Giles 1941). It has also been found that the centric fragment chromosomes in these plants may contain inversions in which crossing-over occurs, as has been noted by Swanson (1940) in a diploid *Tradescantia*. In 299 cells of plant D a bridge in the fragment chromosome, usually with accompanying acentric fragment, was present in 26, (8.5 per cent; fig. 12). The data for the centric fragments are not included with those for the normal chromosomes.

Quantitative Estimation of Hybridity. In an endeavor to obtain some idea of the nature and amount of structural hybridity in the two species and in the hybrid between them, there are three methods of approach, all of which may be used to advantage. In the first place, by observing the pairing relations at metaphase we can determine if reciprocal translocations or duplications (at least in the triploid) are present. The evidence for these, i.e., the unusual configurations in the triploids, has been discussed. It seems clear that duplications are present, although they are undoubtedly small and not very numerous. No configurations indicative of duplications have been noted in the diploid and tetraploid, but, as has been previously pointed out, it is impossible to say that none are present. It is clear that there are no large heterozygous reciprocal translocations in any of the plants, for the expected constant multivalent configurations are absent.

The second and third methods are particularly concerned with determining the amount of inversion hybridity. The most obvious method is to attempt to identify at anaphase I of meiosis specific inversions as shown by their presence in particular chromosomes and by the size of the fragments released, since a single crossover at any point in a given inversion will always release a fragment of the same length. If the chromosomes are individually distinguishable this may be possible. When, however, they are all of about the same size and shape as in the present plants, the method is not so simple. However, it is possible to obtain a reasonably accurate estimate of the minimum number of inversions by taking into account the greatest

number of bridges noted in any one cell, as well as the sizes of the fragments present. In the diploid plant not more than one inversion bridge in any one cell was noted. However, the size of the fragment varies. Although most of the visible fragments are about as long as the width of a meiotic chromosome, occasional smaller or considerably longer fragments occur. This indicates that there are at least three different inversions present. In the tetraploid plant cells were observed with two inversion bridges, the fragments of both being about the same size. Also, as has been mentioned earlier, there were two classes of visible fragments. With this evidence we can say that at least three inversions are present in the chromosomes of the tetraploid. Since, however, we are dealing with four homologous chromosomes in each cell, whose total pairing length is twice that of the diploids, this does not mean that all of the inversions are qualitatively different; that is, that they involve the rearrangement of non-homologous genes. We actually have evidence for only two qualitatively different inverted sequences, since the cells with two bridges having equal fragments may have resulted from crossing-over within two homologous inversions. This difficulty in recognizing qualitatively different inversions does not arise in the triploids in which the pairing length of the three homologous chromosomes is the same as in the diploid. Although it is true that some of the bridges observed in the triploids may be the result of crossing-over following chromosome pairing in aberrant configurations other than heterozygous inversions, it is still at once obvious that we have evidence for many more inversions than in either of the parents. Four bridges were noted in a single cell. We also know that at least one chromosome has an inversion in both arms. Further, the occurrence of a double bridge in one arm with fragments of two different sizes indicates the presence of two separate inversions in one arm or two homologous arms. Consequently, we are justified in assuming a minimum of six different inversions in the triploids.

Obviously, the method just outlined cannot give us an accurate measure of the degree of inversion hybridity, but only an idea of the minimum number of inversions present. A method for obtaining a general quantitative estimate of the total amount of inversion hybridity is that suggested by Darlington (1937b) and termed a *coefficient of hybridity*. This value is obtained by adding together the frequencies of inversion bridges per pollen mother cell and dividing by the average chiasma frequency per cell. It is also necessary in calculating the frequency of bridges to count all double bridges at the first division which result from crossing-over within the same inversion as six instead of two, since, as Darlington points out, these are the result of complementary crossing-over and presumably represent equal numbers of reciprocal crossovers which will not give bridges and disparate crossovers which give only one bridge instead of two. In the present plants,

however, we need not consider this latter point, since the only case of double crossing-over within an inversion was on a slide not included in the data presented.

The result of these calculations for the present group of plants is indicated in table 4. As was pointed out, the frequency of bridges is that observed per pollen mother cell, not per cell. Consequently, the values for the percentages of bridges at anaphase II in table 4 are twice those in table 3.

TABLE 4

Comparative bridge frequencies at anaphase I and II of meiosis in diploid and tetraploid tradescantias and triploid hybrids between them. Calculation of coefficient of hybridity for inversions.

Species	Bridges A I	Bridges A II	Total bridges (Inversion C.O. frequency)	Average Xta per cell	Coefficient of inversion hydridity (cell basis)	Corrected to chromosome basis
T. paludosa (2n)	.057	.042	.099	14.7	.0067	.0067
T. canaliculata (4n)	.185	.074	.259	18.0	.0144	.0072
3n hybrids (average of 6 plants)	.409	.186	.595	13.1	.0454	.0302

Before considering the results obtained, let us first examine the limitations of this method as applied to the present case. Actually the method as outlined is generally applicable only to diploids with a random distribution of chiasmata. Consequently, we are immediately faced with two difficulties, since we are studying triploids and a tetraploid as well as a diploid, and, further, since there is some evidence that crossing-over in diploid tradescantias may be restricted in regions of the chromosomes adjacent to the centromeres.

In order to compare the relative amounts of inversion hybridity in the chromosomes of the diploid and the tetraploid, it is clear that the percentage of bridges should be given on the basis of chromosomes rather than cells. Consequently, we must divide the total percentage of bridges in the tetraploid by two. A further difficulty arises because each chromosome is represented four times in the cells of the tetraploid and consequently the pairing length of homologous chromosomes is potentially twice as great in the tetraploid as in the diploid. For any four homologous chromosomes the gene sequence may be the same in all four, or different in one, two, or three. When the sequence in one of the chromosomes differs from that in the other three, the result of crossing-over will be the same as that in the diploid, unless the chromosome having the inverted sequence fails to pair, in which case the

bridge frequency would be reduced. The same conditions would hold when three chromosomes have an inverted sequence and one is normal. The condition which might produce a considerable difference in bridge frequency in the tetraploid as compared to the diploid is that in which two of the chromosomes have a normal and two an inverted sequence. In such a case preferential pairing between chromosomes having similar sequences may occur, which would reduce the frequency of inversion bridges. However, pairing among the four chromosomes may also be at random. If this occurs, inversion pairing will be present in only four out of the six possible associations. However, in a diploid with a corresponding degree of inversion hybridity, that is, one inversion in one homologous pair, there is no possibility under normal pairing conditions of non-inversion pairing. In consequence, under such circumstances (when there are two identical inverted sequences in two of the four homologous chromosomes) the observed bridge frequency in the tetraploid should be increased by 33 per cent in order to correct for this reduction in bridge frequency due to the type of pairing. It is not possible to ascertain, however, how often when two bridges occur in one cell we are dealing with such identical inverted sequences in homologous chromosomes. It is probable that the fraction would be a rather small one. At any rate these considerations, and those pointed out earlier, indicate that the amount of hybridity as indicated by the percentage of bridges in the tetraploid is certainly a minimum estimate.

In comparing the data for the diploids and triploids certain corrections must also be made. Here again the comparison should be made on the basis of chromosomes rather than of cells. To do this the observed percentage of bridges must be divided by 1.5 since one bridge represents one inverted sequence in 18 chromosomes in the triploid as compared with one in 12 chromosomes in the diploid. The linear order of the homologous sequence in the extra chromosome in the triploid makes no difference since it must be similar to that of one of the other two chromosomes and the percentage of inversion hybridity remains the same in either case. This is true provided the three chromosomes do not differ by inversions involving different breakage points within the same region. Since most of the inversions appear to be small ones, this possibility seems rather unlikely, but it cannot be excluded. The possibility of preferential pairing must also be considered in the triploid. This is especially true in the present plants since we are dealing with what are basically allopolyploids, having two sets of chromosomes from *T. canaliculata* and one from *T. paludosa*. However, the evidence from metaphase pairing indicates that all three sets are largely homologous, since the behavior is that of autopolyploids with somewhat reduced trivalent formation. In triploid *Drosophila melanogaster* females heterozygous for one inversion, the evidence indicates that the two normal chromosomes conjugate and pass to

opposite poles more often than would be expected on random distribution, suggesting that pairing of the chromosome having the inversion is reduced (Sturtevant 1931). In *Tradescantia,* however, since the evidence indicates that crossing-over in diploids may be largely restricted to the distal regions of the chromosomes, the presence of an extra chromosome, even one containing an inversion, would presumably facilitate the association of most of the regions in the chromosome. This should increase the amount of inversion crossing-over, especially if any inversions are located in the regions proximal to the centromere, as recent evidence indicates (Swanson 1940). To believe, however, that the great increase in frequency of bridges in the triploid hybrid plants is due entirely to the type of pairing does not seem warranted. Evidence as to how much the type of pairing in the triploid may be responsible for this increase is obtained from the results on an autotriploid *T. bracteata* (Sax 1937). Here the frequency of bridges at A I was only 16.3 per cent. No data are presented for A II. Since in the autotriploid we have two sets which are identical or nearly so, we should expect the bridge frequency to be even less than in the diploids. If inversion crossing-over coefficients for this plant (for A I) and the average diploid (with approximately 5 per cent bridges) are calculated, the triploid value is approximately three times that of the diploid. In hybrid triploids, however, this increase is about seven times that of the diploid. This must indicate that a considerable part of the increased bridge frequency of the hybrids is due, not to the type of pairing, but to a greater amount of structural hybridity, as would be the case if the sequences contributed by the parents are different. Since the percentage of interstitial chiasmata in the diploid is considerably higher than the average for the triploids and also for the tetraploid (table 1), the calculated inversion hybridity coefficient for this plant should tend to be higher than those for both of the tetraploid and the triploids if inversions are more common in the regions proximal to the centromere (cf. Swanson 1940). It is also true that other anomalous types of pairing in the triploids, such as intra-haploid pairing between relatively inverted segments, may lead to the formation of bridges, and this is another reason why the coefficient of inversion hybridity for the triploids does not have the same validity for comparative purposes as it does for diploids.

As a result of the above considerations, it seems clear that, although the method of calculating coefficients of hybridity for inversions cannot be applied without considerable modification to the comparison of different species of tradescantias in which polyploidy is present, it does permit certain conclusions. These are that the amount of inversion hybridity is least in the diploid *T. paludosa* and somewhat higher in the tetraploid *T. canaliculata* used in this study. Furthermore, it seems clear that the gene sequences of homologous chromosomes within each of the plants of the two species studied

resemble each other more than do the sequences of homologous chromosomes of their hybrid. In other words, in this case the difference in gene sequences is less within an individual of one species than between individuals of two different species.

SUMMARY

A comparative study has been made of the behavior at meiosis of the chromosomes in a diploid *Tradescantia paludosa*, an autotetraploid *T. canaliculata*, and in a number of the triploid hybrids resulting from a cross of these two plants. Certain configurations observed in the triploids, though comparatively rare, indicate the presence of small translocations between, or duplications in, non-homologous chromosomes, and duplication in different arms of the same chromosome. These configurations have not been observed in the diploid or in the tetraploid, but their absence in these plants does not prove the complete absence of the types of hybridity which they indicate. There was no evidence of large heterozygous reciprocal translocations in any of the plants examined. Heterozygous inversions, as indicated by the presence of dicentric bridges and acentric fragments, were present in all the plants studied. The types of bridges and their frequencies in the different plants are described. The various difficulties encountered in making a quantitative estimate of inversion hybridity for comparative purposes in these plants, particularly in the triploids and the tetraploid, are discussed. It is concluded that on a chromosomal basis inversion hybridity in the particular plants used in this study is least in the diploid *T. paludosa*, somewhat greater in the tetraploid *T. canaliculata*, and considerably higher in the triploid hybrids between them, indicating that in this case the differences in the linear order of gene sequences of homologous chromosomes are less within an individual of one species than between individuals of two different species.

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FACTOR Z IN HYBRID MAIZE[1]

WILLIAM J. ROBBINS

(WITH THREE FIGURES)

In an earlier paper (3) it was reported that extracts of the partially germinated grains of a hybrid corn had per embryo, per endosperm or per grain a greater growth-promoting effect upon *Phycomyces* in a solution of minerals, sugar, asparagine and thiamin than those of either of the inbred parents. The growth-promoting effect was ascribed to the presence of an unidentified growth substance called, for convenience, factor Z. The present paper reports the results for extracts of grains of another set of inbred maize and the F_1 offspring.

METHODS AND MATERIALS

The grains used were kindly supplied by Dr. Frederick D. Richey. According to Richey *4–8* is an inbred of some 20 years that is used in a number of corn belt hybrids; *187* is also so used and has been selfed for some 14 years. The cross between them (either way) is the seed parent for United States hybrid *44*, which has had an excellent record in Iowa, Illinois, Indiana, and Ohio. The two hybrids were *985*, a cross of *4–8* × *187*, and *995*, a cross of *187* × *4–8*. The grains were of the 1939 crop and the experiments reported here were performed in March and April, 1940.

The growth-promoting properties were determined by extracting the grains with 5 per cent aqueous pyridine. The pyridine extracts were evaporated nearly to dryness and the residue taken up in distilled water. Aliquots of the extracts were added to a solution of minerals, sugar, asparagine, and thiamin and the mycelial growth of *Phycomyces* was determined for a 72-hour period at 25° C.

The basic solution, solution I, contained per liter 50 g. dextrose, 1.5 g. KH_2PO_4, 0.5 g. $MgSO_4 \cdot 7\ H_2O$, 0.5 mg. thiamin, and asparagine as indicated. The following trace elements also were added in p.p.m., 0.005 B, 0.02 Cu, 0.1 Fe, 0.01 Ga, 0.01 Mn, 0.01 Mo, and 0.09 Zn.

Pyrex glass cleaned with chromic acid cleaning mixture and thoroughly rinsed with tap water and distilled water was used throughout. The dextrose was Corn Products Company C.P.; the asparagine was purified by crystallization from alcohol, the thiamin was Merck's synthetic. Other chemicals were of the usual C.P. grade. The plus strain of *Phycomyces Blakesleeanus* was used. Dry weights of the fungus were determined by filtering the mycelium into Gooch crucibles, washing with distilled water and drying at 100° C.

[1] Assistance in this work was furnished by the personnel of Works Projects Administration Official Project 65–1–97–23 W. P. 5.

EXPERIMENTS

Experiment 1. Twenty grains of each line were placed at 25° C. in a Petri dish with 8 ml. of water. The air-dry weight of each lot of grains was as follows: *4–8*, 4.725 g.; *187*, 5.775 g.; *985*, 4.450 g.; *995*, 4.350 g. After 24 hours each lot of grains was separated into embryos and endosperms. The embryos of each lot were ground in a mortar, as were the endosperms also, and extracted for 24 hours with 50 ml. of 5 per cent aqueous pyridine. The liquid was centrifuged from the solid material and evaporated nearly to dryness on a hot plate. Each extract was made up to 20 ml. with distilled water. One ml. of the final solution was equivalent to the extract of a single embryo or of a single endosperm.

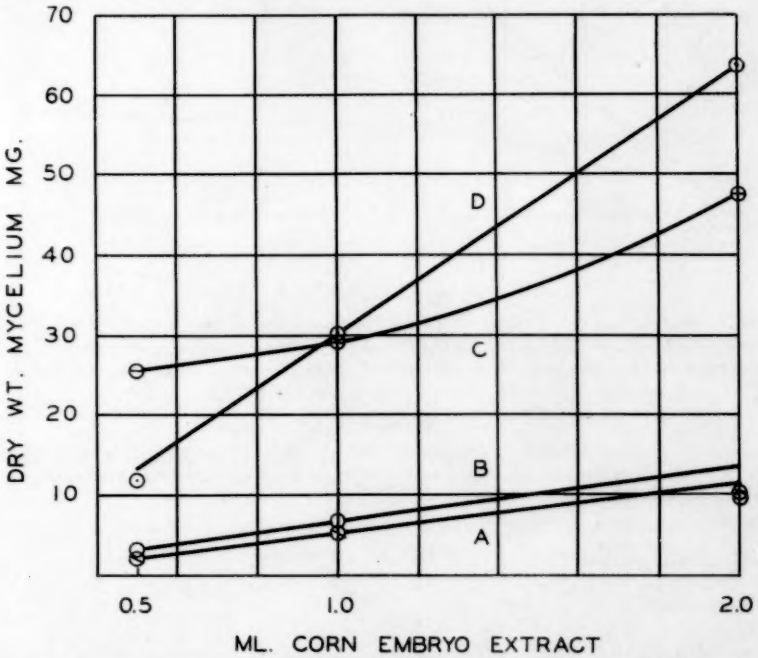

FIG. 1. Increase in dry weight of *Phycomyces* produced by extracts of embryos of maize grains germinated 24 hours. Extracts added to medium of sugar, minerals, asparagine and thiamin. A = line *4–8*, B = line *187*, C = *985*, *4–8* × *187*, D = *995*, *187* × *4–8*. 1 ml. extract = 1 embryo.

The growth-promoting power of each of the 8 extracts was determined by adding aliquots to 25 ml. of solution I containing 2 g. of asparagine per liter. The solutions were inoculated with the spores of *Phycomyces* and incubated at 25° C. The experiment was performed in duplicate. The dry weight of the mycelium produced was determined (table 1) at the end of 72 hours. For constructing the curves in figures 1, 2, and 3 the increase in dry

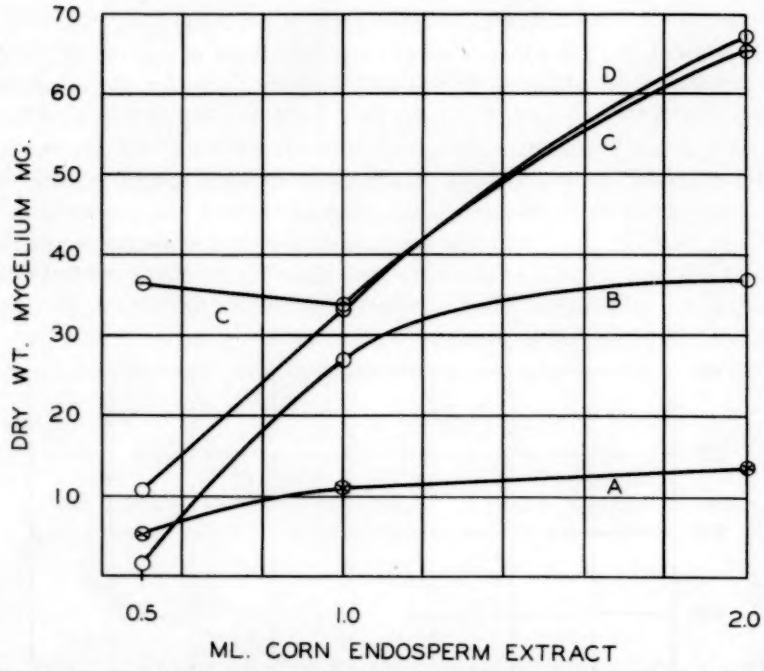

FIG. 2. Increase in dry weight of *Phycomyces* produced by extracts of endosperm of maize grains germinated 24 hours. Extracts added to medium of sugar, minerals, asparagine and thiamin. A = line *4–8*; B = line *187*; C = *985*, *4–8* × *187*; D = *995*, *187* × *4–8*. 1 ml. extract = 1 endosperm.

TABLE 1

Growth-promoting effect of extracts of embryo and endosperm of inbred maize and their F_1 hybrids upon growth of Phycomyces in a solution of minerals, sugar, asparagine, and thiamin. Grains were germinated for 24 hours.

Quantity of extract added per 25 ml. basic medium	Dry wt. mycelium in 2 flasks mg.			
	4–8	*187*	*985*, *4–8* × *187*	*995*, *187* × *4–8*
Embryo				
0.5 grain	7.3	8.2	30.7	17.1
1.0 grain	10.4	11.9	34.3	35.4
2.0 grains	15.2	14.8	62.6	68.9
None	5.1	5.1	5.1	5.1
Endosperm				
0.5 grain	10.4	6.7	41.5	15.8
1.0 grain	16.2	32.1	38.7	38.2
2.0 grains	19.0	42.8	70.6	72.3
None	5.1	5.1	5.1	5.1
Net embryo and endosperm				
0.5 grain	7.5	6.7	41.5	15.8
1.0 grain	16.3	32.1	38.7	38.2
2.0 grains	19.0	42.8	70.6	72.3

weight of the mycelium caused by the extracts was used; the dry weight of the mycelium in the solution with no extract was subtracted in each instance from that obtained in the same medium to which the given quantity of extract had been added. All the extracts increased the growth of *Phycomyces* in the presence of thiamin; those of the endosperms were more beneficial than those of the embryos. The difference between the effectiveness of endo-

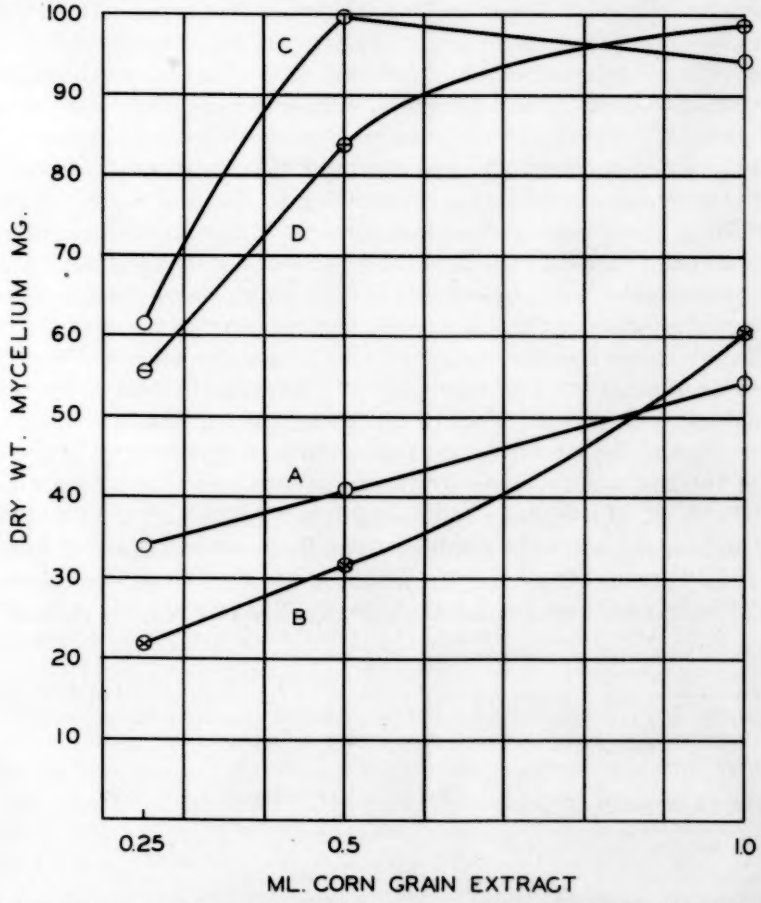

FIG. 3. Increase in dry weight of *Phycomyces* produced by extracts of air dry grains of maize. Extracts added to medium of sugar, minerals, asparagine and thiamin. A = line *4–8*; B = line *187*; C = *985*, *4–8* × *187*; D = *995*, *187* × *4–8*. 1 ml. extract = 1 grain.

sperm and embryo extracts was greater for the inbred parents than for the F_1 hybrids (table 1).

It was found earlier (3) that the amount of factor Z increased with the length of the germination period, at least up to 3 days. It was thought desirable to determine whether this increase was associated with the normal

germination processes or whether it was accounted for by digestion caused by the enzymes of the grain. This was investigated by comparing the growth promoting properties of extracts of dry grains and of grains which had been permitted to autolyze in the presence of toluene.

Experiment 2. Twenty grains of each line were placed in 125 ml. stoppered Erlenmeyer flasks with 8 ml. of distilled water and 0.5 ml. of toluene. The air dry weights of the several lots of grains were as follows: *4–8*, 4.900 g.; *187*, 5.775 g.; *985*, 4.750 g.; *995*, 4.775 g. After 3 days at about 20° C. the grains had swollen materially and softened. They were removed, ground in a mortar and extracted for 24 hours with 50 ml. of 5 per cent aqueous pyridine.

At the same time another lot of 20 grains of each line was selected. The air dry weights were as follows: *4–8*, 4.925 g.; *187*, 5.875 g.; *985*, 4.700 g.; *995*, 4.875 g. These were crushed and ground without the addition of water or toluene and extracted with 50 ml. of 5 per cent aqueous pyridine.

The liquid from each of the 8 lots of corn grains was separated from the solid material by centrifuging and the extract evaporated on a hot plate nearly to dryness. This removed the pyridine and the toluene. The extract of each lot of grain was made up to 20 ml. with distilled water. One ml. of the final solution was equivalent to the extract of 1 grain.

The effect of the 8 extracts upon the growth of *Phycomyces* in the presence of thiamin was determined. The extract of 1, 0.5, or 0.25 grain was added to 25 ml. of solution I containing 2 g. asparagine per liter. The experiment was performed in duplicate. The flasks were inoculated with the spores of *Phycomyces* and the dry weight of the mycelium was determined after 72 hours incubation at 25° C. (table 2). The dry weights of mycelium

TABLE 2

Growth-promoting effect of extracts of grains of inbred maize and their F_1 hybrids upon growth of Phycomyces in a solution of minerals, sugar, asparagine, and thiamin. Above, extracts of autolyzed grains; below, extracts of dry grains.

Quantity of extract added per 25 ml. basic medium	Net dry wt. mycelium in 2 flasks mg.			
	4–8	*187*	*985*, *4–8* × *187*	*995*, *187* × *4–8*
Autolyzed grains				
1 grain	70.2	75.4	86.1	81.8
0.5 grain	59.9	51.2	60.4	65.6
0.25 grain	33.5	41.7	52.8	52.9
Dry grains				
1 grain	54.1	60.2	94.1	98.9
0.5 grain	40.9	31.5	99.8	83.7
0.25 grain	33.9	21.8	61.5	55.5
None	10.5	10.5	10.5	10.5

grown in the presence of the extracts were expressed as the difference between the weights obtained in solutions with extract and that in solutions with no extract added. For example, the dry weight with the extract of 1 grain of the autolyzed *4–8* line was 80.7 mg.; in the check solution 10.5 mg. of mycelium were obtained; the net dry weight was 70.2 mg.

The extracts of the dry grains of the hybrids were more effective than those of either parent (fig. 3). Autolysis increased the potency of the extracts of the parents but decreased that of the extracts of the hybrids. Since the effects of the extracts of the autolyzed grains were not greater for all 4 lines than those of the grains which were not autolyzed it would seem that the increase in factor Z with germination was not merely caused by enzymatic action but was associated with the normal processes of germination.

The dry weights of mycelium obtained with extracts of the dry grains in experiment 2 were greater than those obtained in experiment 1 with grains germinated for 24 hours. This difference is not believed to be significant, because of the influence of differences in the quantity of inoculum and other factors which can be made uniform for a particular experiment but cannot be controlled from experiment to experiment. Furthermore extracts of whole grains were used in experiment 2 while the embryo and endosperm were separately extracted in experiment 1.

DISCUSSION

The results of these experiments confirm earlier findings (3) with another set of inbred maize and their F_1 heterotic hybrid but leave many questions unanswered.

Will other heterotic maize hybrids resemble those which I have investigated? How would the extracts of non-heterotic maize hybrids influence the growth of *Phycomyces* as compared with those of their inbred parents? There are also instances of "negative heterosis" which might be investigated. I have expressed the results in terms of a single embryo, endosperm, or grain. Would similar results be found per gram of material extracted? Would extracts of the grown plants of maize inbreds and their F_1 hybrids differ in their effects upon *Phycomyces* as those of the grains and seedlings apparently do or are the differences described in this paper and an earlier one limited to the seedling stages only? Would the extracts of heterotic hybrids of plants other than maize affect *Phycomyces* as those of maize do? To what may the beneficial effects of the corn extracts on the development of *Phycomyces* be ascribed? The causes for the favorable action of plant extracts upon *Phycomyces* have been discussed at length elsewhere (1, 2, 4) and it seemed probable that unidentified growth substances, called factor Z, were concerned. Robbins and Hamner (5) presented evidence that factor Z is multiple, consisting of at least two parts, factor Z_1 and factor Z_2. Are both

factors concerned in the effects of the corn grain extracts used in this investigation? Is the favorable action due to the addition of organic acids, to changes in hydrogen-ion concentration, to changes in the amount of proportions of minerals, to additions of amino acids, or to some other well known substances rather than unidentified growth substances as we have been inclined to believe?

There are many difficulties in interpreting the effects of plant extracts upon growth because such extracts are mixtures of many organic and inorganic substances, some beneficial, some detrimental, and others ineffective. Until the substances concerned in such an effect as that described in this paper are available in pure form conclusions must be tentative and used primarily as the basis for further experimentation.

SUMMARY

Extracts of the grains of two inbred strains of maize and their heterotic F_1 hybrids were found to increase the early growth of *Phycomyces* in solutions of sugar, minerals, asparagine, and thiamin. The extracts of the hybrid grains produced a greater effect per grain, per embryo, and per endosperm than those of either of the parents. The effect of extracts of autolyzed grains differed somewhat from those which were allowed to germinate for 24 hours.

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THE DEVELOPMENT OF THE EMBRYO SAC IN AGAVE VIRGINICA

LORRAINE REGEN

(WITH FOURTEEN FIGURES)

The vast majority of Angiosperms in which the development of the macrogametophyte has been studied are characterized by an embryo sac of the "normal" type, which is 8-nucleate at maturity, and formed from a single macrospore nucleus in consequence of three nuclear divisions (Maheshwari, 1937). Until recently, *Lilium* has been used as the customary material for the demonstration of embryo sac development to students of elementary botany. It has been shown, however, by Bambacioni (1928, 1932) and Cooper (1934, 1935) that the eight nuclei of the mature embryo sac of *Lilium* are derived from four macrospore nuclei rather than one, and that this 8-nucleate stage is separated from the macrospore nuclei by only two nuclear divisions rather than three. Hence the development of the embryo sac in *Lilium* does not conform to the "normal" type, but is referred to the so-called "Fritillaria" type of Maheshwari (1937).

Several years ago, Dr. Harold C. Bold became interested in attempting to find other favorable material to demonstrate the "normal" type of embryo sac development, and suggested that *Agave virginica* L. (Amaryllidaceae, subfamily Agavoideae) might prove suitable for this purpose. Apparently the only previous cytological work dealing with embryo sac development in this genus is that of Schlimbach (1924), on *Agave chloracantha* and *A. attenuata,* as well as several other representatives of the Amaryllidaceae. This worker concluded that embryo sac development proceeded according to the "normal" type in species whose ovules are surrounded by two integuments, but that development of species with one integument was of the "Lilium" type (as it was understood at that time, now called the "Adoxa" type).

MATERIALS AND METHODS

The inflorescence of *A. virginica* is a panicle or compound raceme, in which many flowers are borne in acropetal succession. It was very easy, therefore, to secure numerous flower buds in all stages of development. The material on which the present study is based was collected by Dr. Harold C. Bold near Knoxville, Tenn., in the summer of 1938, and fixed in a modified Bouin's solution called Allen's B–15.[1] After washing, the material was dehydrated in an alcohol series, cleared in xylol, and, following infiltration, was embedded in paraffin. Sections were cut at a thickness of

[1] This formula is given by McClung (1929).

10 μ and 15 μ, stained with Heidenhain's iron alum hematoxylin, and counterstained with fast green.

OBSERVATIONS

The flowers of *A. virginica* have an inferior ovary, as is characteristic of the family Amaryllidaceae. In each of the three locules of the ovary are borne two rows of ovules with axile placentation; the ovules themselves are anatropous. Certain cells of the ovary wall are conspicuous because they contain groups of calcium oxalate crystals of the raphides type.

The outer integument of the ovule is from one to three cells thicker than the inner integument, which is usually two cells thick. Within the nucellus, the primary archesporial cell or macrospore mother cell, hypodermal in position, is distinguished from the surrounding cells by its larger size (fig. 1). During the prophases of the heterotypic division the chromatic strands are first evenly distributed throughout the large nucleus, later aggregated in a dense netted mass toward one side. The nucleus generally contains a single large nucleolus, but occasionally there are two nucleoli lying close together. As the chromosomes take definite shape, they become distributed around the periphery of the large prophase nucleus.

Following the metaphase (fig. 2) and telophase (fig. 3) of the heterotypic division, a cell wall is formed separating the two cells of the dyad (fig. 4). The succeeding homoeotypic division, of which a telophase stage is shown in figure 5, is also followed by wall formation so as to delimit the four macrospores.

The arrangement of the macrospores in the tetrad is either of the linear type (fig. 6) or the "T-shaped" type (fig. 7). In several ovules a row of three reproductive cells was observed with no fourth cell in the adjacent sections; this is possibly to be interpreted as comprising two macrospores and an undivided cell of the dyad.

In every case observed, it is the chalazal macrospore which develops into the embryo sac (fig. 8). The densely staining remnants of the three disintegrating macrospores may be seen at the micropylar end of the enlarging gametophyte as late as the four-nucleate stage (fig. 10).

The nucleus of the chalazal macrospore divides to form a two-nucleate embryo sac (fig. 9). These two daughter nuclei then divide again, forming a four-nucleate macrogametophyte (fig. 10). With the final division of each of these four nuclei, the embryo sac becomes eight-nucleate (fig. 12). At this stage three antipodal cells are formed at the chalazal end of the embryo sac (fig. 11–13), two synergids and an egg cell are formed in the micropylar end (fig. 12–13), and the two polar nuclei migrate toward the center of the embryo sac (fig. 12).

Certain nuclear changes within the embryo sac may occur before fer-

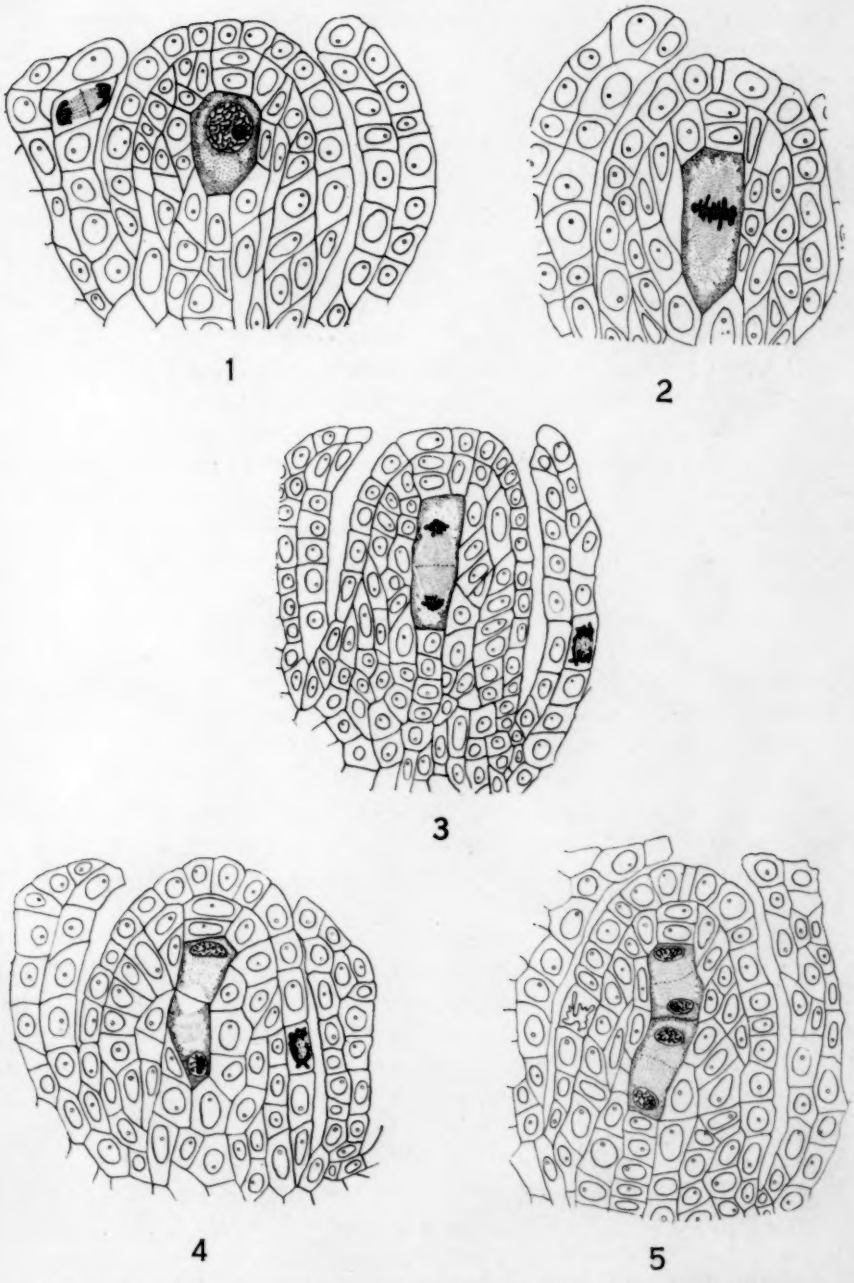
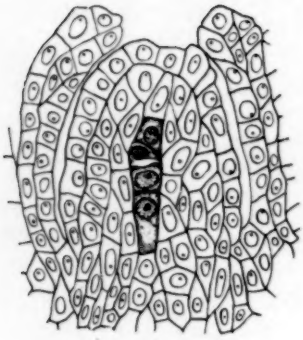


FIG. 1. Early prophase of heterotypic division in the macrospore mother cell. ×320. FIG. 2. Metaphase of heterotypic division. ×340. FIG. 3. Telophase of heterotypic division. ×260. FIG. 4. Dyad formed after heterotypic division. ×340. FIG. 5. Late telophase of homeotypic division. ×300.



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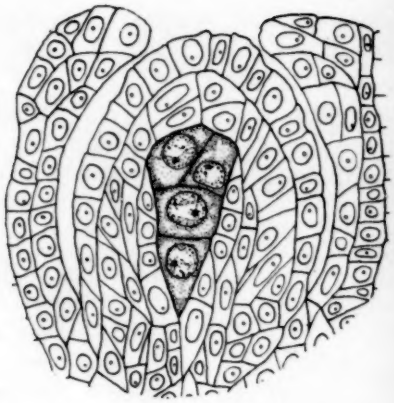

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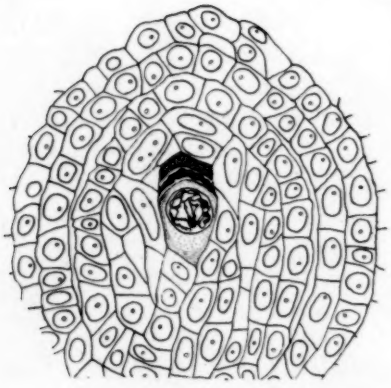

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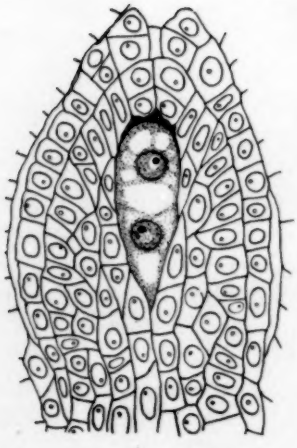

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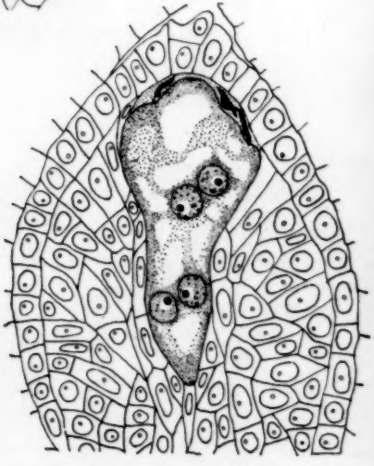

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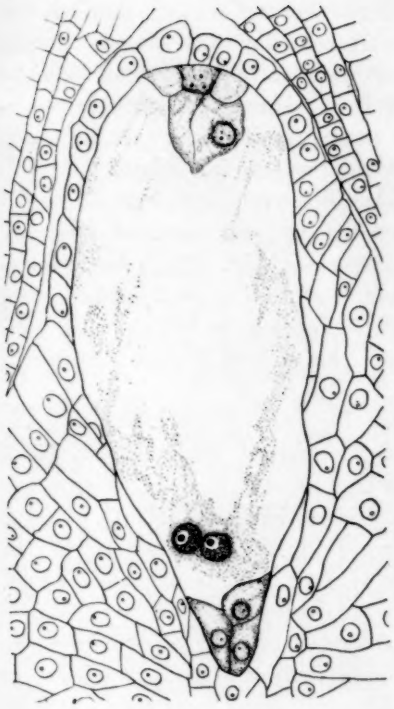
FIG. 6. Tetrad of macrospores showing linear arrangement. ×185. FIG. 7. "T-shaped" tetrad of macrospores. ×340. FIG. 8. Developing chalazal macrospore with two degenerating macrospores. ×250. FIG. 9. Two-nucleate embryo sac. ×200. FIG. 10. Embryo sac at four-nucleate stage, with persistent remnants of three disintegrated macrospores. ×200.



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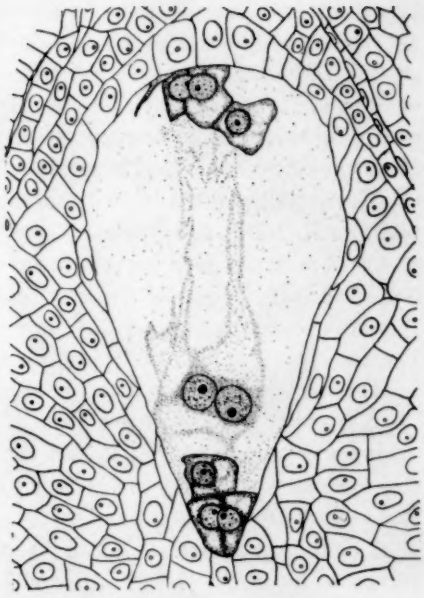

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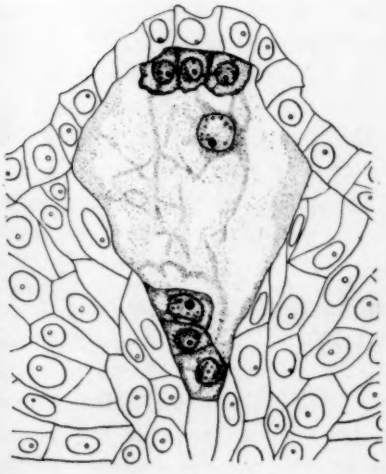

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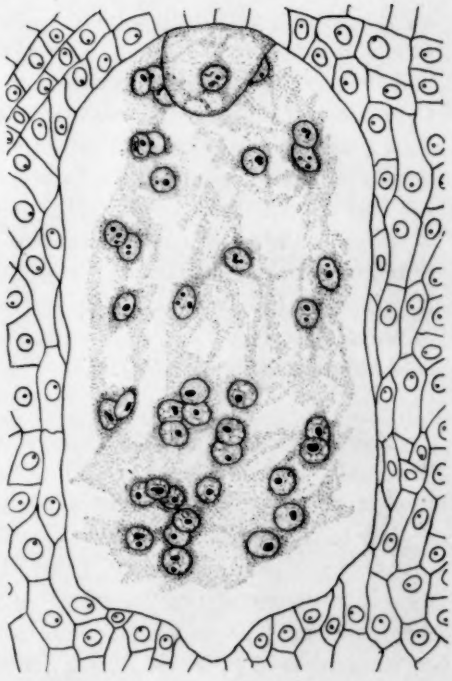

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FIG. 11. Nearly mature embryo sac with egg cell, two degenerating synergids, two polar nuclei, and three antipodals. ×200. FIG. 12. Eight-nucleate embryo sac of "normal" type. ×200. FIG. 13. Embryo sac showing primary endosperm nucleus. ×200. FIG. 14. Composite drawing from several adjacent sections, showing endosperm in free-nuclear condition. ×200.

tilization is accomplished. In some cases the synergids (fig. 11) or the antipodals may become disorganized prior to fertilization. The two polar nuclei frequently fuse to form the primary endosperm nucleus, so that the embryo sac is seven-nucleate (fig. 13). This fusion is not of invariable occurrence, however; in certain cases the polar nuclei may remain unfused until after the degeneration of the synergids, of the antipodals, or both.

The actual process of fertilization was not observed in any of the material studied. The most mature ovules examined showed, however, that the endosperm in its early development is free-nuclear (fig. 14). A large number of endosperm nuclei lie in the cavity occupied by the embryo sac before the embryo has begun its development. This observation is in accord with the findings of Schlimbach (1924), who reported a free-nuclear endosperm in *A. chloracantha* and *A. attenuata*.

A number of departures from the normal course of development in *A. virginiana* were observed in the course of the present work. One ovule of this species was found to contain two distinct nucelli, enclosed within the same outer integument, but having separate inner integuments. An account of a similar circumstance has been reported in *Moringa oleifera* of the Liliaceae by Puri (1934). In another ovule, two tetrads of macrospores, each linear in nature, were observed within a single nucellus.

It was noted, furthermore, that a considerable number of ovaries in *A. virginica* were very unproductive. Many of the ovules of such ovaries were sterile and abortive, forming no reproductive cells, and some were actually hollow because of the degeneration of nucellar and sporogenous tissue. Cappelletti (1927), studying deteriorative processes within ovules of *A. chloracantha* in which fertilization was inhibited, described a brief hypertrophy of the nucellar nuclei, followed by cellular degeneration of this tissue and a breakdown of the embryo sac. A similar degeneration occurs in *A. virginica* also; in some cases even after the embryo sac has reached the four-nucleate stage. Likewise Catalano, working with *A. zapupe* (1928) and *A. sisalana* (1929a) noted abnormalities during macrosporogenesis and consequent sterility in these forms, which he would attribute to their probable hybrid nature (1929b).

DISCUSSION

Macrosporogenesis and embryo sac development in *A. virginica* is of the "normal" type, as described by Maheshwari (1937). In this respect, and also in the free-nuclear nature of the young endosperm, *A. virginica* is similar to *A. chloracantha* and *A. attenuata* (Schlimbach 1924). It is hoped that this species may furnish a useful and appropriate material for laboratory illustration of the "normal" type of embryo sac development in the Angiosperms. The occasional abnormalities noted are not of such common occurrence as to preclude its use for this purpose, to which it seems ideally adaptable because of the large size of the nuclei and the embryo sac itself.

McKelvey and Sax (1933) and Whitaker (1934) have suggested that *Agave, Fourcroya, Polyanthes,* and *Beschorneria* of the Amaryllidaceae represent the epigynous counterparts of the hypogynous Liliaceae *Yucca, Hesperoyucca, Hesperaloe, Cleistoyucca,* and *Samuela.* This suggestion is based on the fact that all of these genera have an identical haploid chromosome complement consisting of five large and twenty-five small chromosomes. The present work, showing that *Agave* is like *Yucca* (Wolf 1940, et al.) in having a "normal" type of embryo sac, would tend to strengthen this point of view.

SUMMARY

In *Agave virginica* L. the macrospore mother cell forms four macrospores, which may have either a linear or a "T-shaped" arrangement. The chalazal macrospore, by three nuclear divisions, forms an embryo sac of the "normal" eight-nucleate type, which becomes seven-nucleate following the fusion of the two polar nuclei to form the primary endosperm nucleus. Both the synergids and the antipodals may degenerate before fertilization. Endosperm formation is free-nuclear, and may proceed to a considerable extent before development of the embryo has begun. Degeneration of the embryo sac and nucellus in unfertilized ovules has been observed.

The author wishes to express her sincere thanks to Dr. Harold C. Bold for suggesting the problem and supervising the early stages of this work, and to Dr. Fred T. Wolf for his assistance in the preparation of the drawings and the manuscript.

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SUPPLEMENTARY NOTES ON AMERICAN MENISPERMACEAE

B. A. Krukoff and H. N. Moldenke

Considerable progress has been made recently in the chemical studies of the alkaloids derived from certain members of the *Menispermaceae* (3) and in the studies of botanical components of various Curare (1, 2, 6, 7). In connection with this continuous interest in Curare, a number of menispermaceous specimens have been received for identification which extend our knowledge of certain species. Extensions of ranges are noted for a number of species and one species is described as new. It is satisfactory that, although a considerable number of specimens has been examined, no changes in nomenclature appear to be necessary at the present time.

The species are arranged in the same order and the place of deposit of specimens is shown by the same abbreviations as in our previous papers (4, 5). The following new abbreviations are used:

A: Arnold Arboretum, Harvard University.
D: Academy of Natural Sciences, Philadelphia.
E: Missouri Botanical Garden, St. Louis.
Mi: University of Michigan, Ann Arbor.

chondodendron Ruíz & Pavon

1. Chondodendron microphyllum (Eichl.) Moldenke. Additional specimens examined: Brazil—bahia: *Blanchet 1594* (F), *3178a* (F), *s.n.* (F).

2. Chondodendron platiphyllum (A. St. Hil.) Miers. Additional specimens examined: Brazil—rio de janeiro: *St. Hilaire s.n.* (Macbride photo 34501; type coll. of *Cocculus ? cinerascens*) (F—photo). state undetermined: *Martius 510* (Macbride photo 19125; type coll. of *C. aemulum*) (E, F, G—photo). bahia: *Luschnath* or *Lhotsky 173* (E).

In his recent paper (3, p. 737) dealing with the alkaloids of *Chondodendron* spp. Dr. King states: "The aim of this investigation was the determination of the botanical source of the substance known in pharmacy as *radix pareirae bravae*, since its alkaloids are related to the phenolic alkaloids of tube- and pot-curare. This object has been attained. When *pareira brava* yields l-bebeerine it comes from *Chondodendron platyphyllum* and when it yields d-bebeerine from *Ch. microphyllum.*" In another place in the same paper (3, p. 739) he states: "*Chondodendron platyphyllum* and *microphyllum* are two species whose taxonomical characters are very close, but chemical examination shows a clear distinction. Since it is unlikely that native plant collectors could distinguish these species and there is no apparent difference in the pharmacognostical characters of their roots, it seems clear that *pareira brava* has originated in the past in these two species."

It is thus satisfactory that our suggestion in a previous paper (4, p. 15) as to the botanical source of "pareira brava" has been fully confirmed.

3. CHONDODENDRON TOMENTOSUM Ruíz & Pav. Additional specimens examined: PERU—SAN MARTÍN: basin of Río Huallaga, *Klug 4044* (E, F, G, W); *Spruce 4474* (Macbride photo 34500; type coll. of *C. cretosum* and *Botryopsis Spruceana*) (F, F—photo, G). JUNÍN: basin of Río Perene, *Killip & Smith 27175* (F).

5. CHONDODENDRON LIMACIFOLIUM (Diels) Moldenke. Additional specimens examined: BRAZIL—AMAZONAS: basin of Rio Solimoes, *Krukoff 8370* (W), *8522* (W), *8713* (W). PARÁ: *Sigueira 8266* (Macbride photo 4993) (G—photo of type).

6. CHONDODENDRON TOMENTOCARPUM (Rusby) Moldenke. Additional specimens examined: BOLIVIA—LA PAZ: basin of Río Beni, *O. E. White 1812* (type coll. of *Abuta boliviana*) (G, Mi, W).

7. CHONDODENDRON TOXICOFERUM (Wedd.) Krukoff & Moldenke. Additional specimens examined: PERU—LORETO: basin of Río Huallaga, *Killip & Smith 28665* (F); *Klug 2782* (E, F, G); basin of Río Itaya, *Killip & Smith 29337* (F); basin of Río Putumayo, *Klug 2042* (E, F, G, Mi). BRAZIL: basin of Rio Jurua, *Ule 5631* (Macbride photo 4985; type coll. of *C. polyanthum*) (F, G—photo).

SCIADOTENIA Miers

1. SCIADOTENIA SAGOTIANA (Eichl.) Diels. Additional specimens examined: FRENCH GUIANA: *Sagot 19* (Macbride photo 4987) (G—photo of type).

2. SCIADOTENIA PARAËNSIS (Eichl.) Diels. Additional specimens examined: BRAZIL—PARÁ: *Martius s.n.* (Macbride photo 19124) (G—photo of type).

3. SCIADOTENIA SOLIMOESANA Moldenke. Additional specimens examined: BRAZIL—AMAZONAS: basin of Rio Solimoes, *Krukoff 8243* (A), *8385* (A—isotype).

4. SCIADOTENIA EICHLERIANA Moldenke. Additional specimens examined: BRAZIL—AMAZONAS: basin of Rio Solimoes, *Krukoff 8279* (A—isotype, W—isotype), *8376* (A).

6. SCIADOTENIA RAMIFLORA Eichl. Additional specimens examined: PERU—LORETO: basin of Río Huallaga, *Poeppig 2271* (Macbride photo 4986) (G—photo of type); basin of Río Amazonas, *Klug 1299* (W).

7. SCIADOTENIA DUCKEI Moldenke. Additional specimens examined: BRAZIL—AMAZONAS: *Ducke 409* (A—isotype, F—isotype).

8. SCIADOTENIA AMAZONICA Eichl. Additional specimens examined: BRAZIL—AMAZONAS: *Martius s.n.* (Macbride photo 19126) (G—photo of type).

9. SCIADOTENIA CAYENNENSIS Benth. Additional specimens examined: FRENCH GUIANA: *Collector undesignated s.n.* (F). BRITISH GUIANA—ESSEQUIBO: basin of Takutu River, *A. C. Smith 3581* (E).

Dr. Smith gives the following notes: "Slender liana; fruit often on stem near base, the leaves above; fruit orange, at length deep purple." The collection is the first known record of the species from British Guiana.

10. SCIADOTENIA BRACHYPODA Diels. Additional specimens examined: BRAZIL—AMAZONAS: basin of Rio Jurua, *Krukoff 5096* (A, Mi, W); basin of Rio Purus, *Goeldi 3934* (Macbride photo 4984) (G—photo of isotype).

11. SCIADOTENIA SIMILIS Moldenke. Additional specimens examined: BRAZIL—AMAZONAS: basin of Rio Negro, *Krukoff 8020* (A—isotype).

ANOMOSPERMUM Miers

1. ANOMOSPERMUM SCHOMBURGKII Miers. Additional specimens examined: PERU—SAN MARTÍN: basin of Río Huallaga, *Klug 3739* (A, E, F, G, W), *3756* (E, F, G). HUANUCO: *Mexia 8201* (E, G, W). LORETO: basin of Río Nanay, *Klug 1191* (W), *1370* (F, W). BOLIVIA—LA PAZ: basin of Río Beni, *Buchtien 1619* (G). BRAZIL: Amazonas: basin of Rio Negro, *Spruce 2563* (Macbride photo 34503; type coll. of *A. lucidum*) (F, F—photo, G). Rio de Janeiro: *Glaziou 13516* (Macbride photo 4997) (A, F, G—photo). Surinam: *Hostmann 1298* (Macbride photo 30147; type coll. of *A. Hostmanni*) (F—photo, G). BRITISH GUIANA: *Rob. Schomburgk 833* (Macbride photo 30148) (F—isotype, F—isotype, F—photo of isotype, W—isotype). DEMERARA: basin of Demerara River, *De la Cruz 2682* (D, G, W). ESSEQUIBO: basin of Essequibo River, *De la Cruz 1436* (D, E, W), *1732* (E, W); basin of Mazaruni River, *De la Cruz 2267* (D, E, Mi, W), *2285* (D, E, W), *2360* (E, W), *2835* (D, E, G, W). TRINIDAD: *W. E. Broadway 7552* (W).

The Mexia collection cited above represents the first known record of this species from Huanuco. The collector records the vernacular name "huano" and states that the mature fruit is orange. The New York Botanical Garden sheet of *Buchtien 619* is plainly so labeled, but the Gray herbarium sheet has had the number corrected to "1619." The reason for this correction is not clear. The Broadway collection cited above is apparently the first record of the species from Trinidad.

2. ANOMOSPERMUM DIELSIANUM Moldenke. Additional specimens examined: BRAZIL—AMAZONAS: basin of Rio Solimoes, *Krukoff 9045* (A—isotype).

3. ANOMOSPERMUM RETICULATUM (Mart.) Eichl. Additional specimens examined: BRAZIL—AMAZONAS: basin of Rio Japura, *Martius 3027* (Macbride photo 19128) (G—photo of cotype); basin of Rio Madeira, *Krukoff 6766* (A).

4. ANOMOSPERMUM NITIDUM Miers. Additional specimens examined: BRAZIL—RIO DE JANEIRO: *Miers 4254* (F—isotype); *Glaziou 13517* (F).

6. ANOMOSPERMUM CHLORANTHUM Diels. Additional specimens examined: BRAZIL—AMAZONAS and ACRE TERRITORY: basin of Rio Purus, *Ule 9388* (Macbride photo 4996) (F—isotype, G—photo of type); basin of Rio Solimoes, *Krukoff 9118* (A).

TELITOXICUM Moldenke

1. TELITOXICUM KRUKOVII Moldenke. Additional specimens examined: BRAZIL—AMAZONAS: basin of Rio Madeira, *Krukoff 6912* (A—isotype).

2. TELITOXICUM PERUVIANUM Moldenke. Additional specimens examined: PERU—LORETO: basin of Río Putumayo, *Klug 2129* (E—isotype).

5. TELITOXICUM DUCKEI (Diels) Moldenke. Additional specimens exam-

ined: BRAZIL—PARÁ: basin of Rio Mapuera, *Ducke 9012* (Macbride photo 4990) (G—photo of type).

6. TELITOXICUM MINUTIFLORUM (Diels) Moldenke. Additional specimens examined: PERU—LORETO: basin of Río Marañon, *Tessmann 4565* (F—isotype). BRAZIL—AMAZONAS: basin of Rio Solimoes, *Krukoff 7559* (A), *8840* (A, W); basin of Rio Negro, *Krukoff 7956* (A), *8033* (A).

ABUTA Barrère

1. ABUTA MACROCARPA Moldenke. Additional specimens examined: BRAZIL—AMAZONAS: basin of Rio Negro, ? *Krukoff 7961* (A), ? *7994* (A).

2. ABUTA OBOVATA Diels. Additional specimens examined: BRITISH GUIANA—ESSEQUIBO: basin of Mazaruni River, *De la Cruz 2250* (D—isotype, E—isotype, G—isotype, W—isotype).

3. ABUTA BULLATA Moldenke. Additional specimens examined: BRAZIL—AMAZONAS: basin of Rio Madeira, *Krukoff 7051* (A). BRITISH GUIANA—ESSEQUIBO: basin of Potaro River, *Gleason 727* (W).

5. ABUTA VELUTINA Gleason. Additional specimens examined: VENEZUELA—AMAZONAS: basin of Río Orinoco, *Tate 959* (W—isotype).

6. ABUTA PANURENSIS Eichl. Additional specimens examined: BRAZIL—AMAZONAS: basin of Rio Negro, *Spruce 2763* (Macbride photo 4994) (G—photo of isotype).

7. ABUTA RACEMOSA (Thunb.) Triana & Planch. Additional specimens examined: COLOMBIA: department undesignated, *Mutis 5632* (W), *5759* (W).

8. ABUTA IMENE (Mart.) Eichl. Additional specimens examined: BRAZIL—AMAZONAS: basin of Rio Negro, *Spruce s.n.* (in vicinibus Barra; Macbride photo 4992; type coll. of *A. rigida*) (F, G, G—photo).

10. ABUTA TRINERVIS (Rusby) Moldenke. Additional specimens examined: BOLIVIA—LA PAZ: basin of Río Mapiri, *Buchtien 1935* (W—isotype).

11. ABUTA GRANDIFOLIA (Mart.) Sandw. Additional specimens examined: VENEZUELA—BOLÍVAR: *Ll. Williams 11437* (F, F, W). PERU—SAN MARTÍN: basin of Río Huallaga, *Klug 2757* (A, E, G). LORETO: basin of Río Huallaga, *Klug 3006* (A, E, G); basin of Río Amazonas, *Klug 2526* (A, W). COLOMBIA—PUTUMAYO: *Klug 1962* (A, E, G). VAUPÉS: *Cuatrecasas 6931* (W). BOLIVIA—LA PAZ: basin of Río Beni, *H. H. Rusby 1979* (D, E, G, Mi). BRAZIL—GOYAZ: *Froes 2065* (A, Mi). MATTO GROSSO: *Malme 1484* (G). MARANHÃO: *Froes 11829* (N). ACRE TERRITORY: basin of Río Purus, *Krukoff 5786* (A, W). AMAZONAS: basin of Rio Jurua, *Krukoff 4720* (A, Mi); basin of Rio Madeira, *H. H. Rusby 1980* (Mi); basin of Rio Solimoes, *Poepping 3069* (type coll. of *A. concolor*) (F); *Krukoff 7812* (A); basin of Rio Negro, *Spruce 1829* (cotype coll. of *Anelasma pallidum*) (G), *s.n.* ("in vicinibus Barra") (G); *Krukoff 7998* (A). PARÁ: *Ducke 275* (A, F). BRITISH GUIANA—ESSEQUIBO: basin of Takutu River, *Rich. Schomburgk 440* (Macbride photo 30152; type coll. of *Anelasma Guianense* (F, F—photo). BERBICE: basin of Berbice River, *De la Cruz 1646* (E). SURINAM: *Collector undesignated s.n.* ("D," 23–VII–1939) (N).

Cuatrecasas' specimen is the first known record of the species for the

province of Vaupés (Colombia), Froes' specimen the first record from the State of Maranhão (Brazil).

The vernacular name "oeralime" is recorded on the label of the specimen from Surinam.

12. ABUTA KLUGII Moldenke. Additional specimens examined: BRAZIL—AMAZONAS: basin of Rio Madeira, ? *Krukoff 7185* (A, E).

13. ABUTA SELLOANA Eichl. Additional specimens examined: BRAZIL: *Sellow s.n.* (D). SÃO PAULO: *F. C. Hoehne s.n.* (Herb. Inst. Biol. S. Paulo 28429) (A). RIO DE JANEIRO: *Glaziou 13403* (F). MINAS GERAES: *Mexia 4456* (A, D, E, G), *5082* (A, D, E, G); *Mello Barreto 1662* (N), *1777* (F), *1950* (F).

14. ABUTA RUFESCENS Aubl. Additional specimens examined: BRAZIL: *Casaretto 1855* (F). RIO DE JANEIRO: *Guillemin 639* (type coll. of *Cocculus ? macrophylla*) (F); *Martius 306* (Macbride photo 19129) (G—photo). MINAS GERAES: *Mexia 4215* (G), *5478* (A, A, D, E, E, G). AMAZONAS: basin of Rio Madeira, *Krukoff 5978* (A, Mi, W); basin of Rio Purus, *Krukoff 5437* (A, E, Mi, W).

16. ABUTA GRISEBACHII Triana & Planch. Additional specimens examined: BRAZIL—AMAZONAS: basin of Rio Solimoes, *Krukoff 7570* (A), *7572* (W), *7822* (A), *8660* (A); basin of Rio Negro, *Krukoff 7960* (A), *7976* (A), ? *8030* (A); *Ducke 415* (A, F); *Spruce 2340* (Macbride photo 4991) (F—cotype, G—cotype, G—photo of cotype).

17. ABUTA CANDOLLEI Triana & Planch. Additional specimens examined: BRITISH GUIANA: basin of Mazaruni River, *Tutin 188* (W). SURINAM: *Collector undesignated s.n.* ("E," 16.VII.1939) (N). FRENCH GUIANA: *Sagot s.n.* (Macbride photo 34498) (F—photo of type); *Perottet s.n.* (F); *Aublet s.n.* (Macbride photo 34499) (F, F—photo).

If the Paris specimen of *Aublet s.n.* (of which we have seen a fragment and a photograph in the Field Museum herbarium) proves to be conspecific with the British Museum specimen which is the type of *A. rufescens* Aubl., then *A. rufescens* will have to be the name adopted for what is now called *A. Candollei*, and the plant now known as *A. rufescens* will have to have a new name.

Tutin's collection is the first record of the species from British Guiana.

18. **Abuta splendida** Krukoff & Moldenke, sp. nov. Frutex scandens; laminis coriaceis ovatis vel late ellipticis, ad apicem abrupte breviterque mucronatis, ad basim rotundatis, supra nitidis, subtus dense adpresso-tomentosis, 5-plinerviis; drupis magnis 2.8–3.1 cm. longis, 1.8–2 cm. latis, asymmetricis.

In our previous paper (5, p. 70) the Buchtien specimens cited below were placed under *A. Candollei* with reservations. They exhibit only pistillate flowers and mature fruits, neither of which was available on any of the specimens from the Guianas which are undoubtedly the true *A. Candollei*. Since then we have received an excellent sheet with mature fruit (*collector undesignated s.n.*) collected on July 16, 1939, at Litanie, in Surinam, and

kindly sent to us by Prof. Dr. G. Stahel, also additional sheets of the Bolivian plant collected by the senior author of this paper in 1939 in the basins of the Río Bopi and Río Mapiri.

It is now obvious that the Bolivian plant represents a distinct species. Its fruits are 2.8–3.1 cm. long, 1.8–2 cm. wide, distinctly asymmetric at the base, curved, the mesocarp hard, about 2 mm. thick, and the pedicels 2–3.5 mm. in diameter, whereas in *A. Candollei* the fruits are 1.7–2.1 cm. long, 1.3–1.5 cm. wide, more or less symmetric at the base, and straight, the mesocarp about 0.5 mm. thick, and the pedicels up to 1 mm. in diameter.

Only staminate flowers are known from *A. Candollei* and only pistillate flowers are known from the new species from Bolivia. In our previous paper (4, p. 70) we have already pointed out the differences in the pistillate flowers between the Bolivian plant and *A. Grisebachii*, the only other species of the genus in which the leaf-blades are woolly beneath (completely covered with hairs!). The pistillate flowers of the new species differ from those of *A. Grisebachii* in their much longer and wider sepals, which are distinctly appressed-pubescent with short antrorse buff hairs which project conspicuously in ciliate fashion over the margins, longer staminodes, and larger ovaries.

Description: A woody vine; older branchlets stout, solid, subappressed-tomentose, the pubescence wearing off with age; younger branchlets stout, very densely appressed-tomentose with brownish or cinereous hairs; petioles slender, 2.5–9.5 cm. long, densely subappressed-tomentose with cinereous hairs when young, less so in age, curved and incrassate at apex, ampliate at base; leaf-blades coriaceous, ovate or broadly elliptic, 8–20.5 cm. long, 4.9–13 cm. wide, from rounded to acuminate and invariably abruptly short-mucronate at apex, entire, rounded at base, glabrous above except for the midrib and primary veins near the base which are often subappressed-tomentose with cinereous hairs, densely appressed-tomentose with cinereous hairs below, 5-plinerved, the primary veins and their branches somewhat impressed above, very prominent beneath, the inner pair of primary veins issuing at the very base of the blade; secondaries rather numerous, issuing at approximately right angles to the primaries, subparallel to each other, regular, distinct or often indistinct under a hand-lens above, very prominent beneath; veinlet reticulation fine and abundant, hardly distinct under a hand-lens above, prominent beneath; rachis subappressed-tomentose, the pubescence wearing off with age, greatly incrassate in fruit; fruiting-pedicels stout, 4–9 mm. long, 2–3.5 mm. in diameter, pubescent like the rachis, each bearing 1, 2, or 3 fruits; torus very greatly enlarged and club-shaped in fruit; fruits drupaceous, basally attached, elliptic, 2.8–3.1 cm. long, 1.8–2 cm. wide, asymmetric at the base, curved, the exocarp hard, densely subappressed-tomentose with cinereous hairs, the pubescence wearing off with age, the mesocarp dark-brown, hard, about 2 mm. thick, the endocarp bony, sculptured; embryo folded over the condyle, each arm about 1.6 cm. long.

Specimens examined: BOLIVIA—LA PAZ: basin of Río Bopi, *Krukoff 10652* (N); basin of Río Mapiri, *Krukoff 10802* (N), *10866* (N), *10927* (N), *11083*

(fr. Oct.–Nov.) (N—type); *Buchtien 620* (fr. Sept.), (N, G), *1676* (fl. June) (W), *1901* (fr. Sept.) (N, W, W).

The species is very common on a hill on the right bank of the Río Bopi near Malpaso del Cinco, also near Florida (between Mapiri and San Carlos) in the basin of the Río Mapiri. The New York Botanical Garden specimen *Buchtien 620* is plainly inscribed "620," while the Gray herbarium specimen has had its number corrected to "1620." The reason for this correction is not clear.

ELISSARRHENA Miers

1. ELISSARRHENA GRANDIFOLIA (Eichl.) Diels. Additional specimens examined: BRAZIL—AMAZONAS: basin of Rio Jurua, *Krukoff 4673* (A, F); basin of Rio Negro, *Spruce 1538* (Macbride photo 19130) (G—photo of type).

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NEW YORK, NEW YORK

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NOVELTIES IN THE MELASTOMACEAE

H. A. Gleason

Among the specimens referred to me for identification during the past twelve months are several apparently new to science. These are here described. All types have been deposited in the Britton Herbarium at the New York Botanical Garden.

Weberbauer collected in 1904 a Peruvian melastome which was described by Cogniaux in 1908 as the only species in a new genus, *Centradeniastrum*. So far as I know, it has not been re-collected. Cuatrecasas and Arbeláez have recently collected a second species in Colombia.

Centradeniastrum album Gleason, sp. nov. A *C. roseo* differt floribus 5-meris ovario 3-loculari foliis late cordato-ovatis.

Stem slender, freely branched, glabrous, about 5 dm. long. Petioles slender, glabrous, nearly as long as the blade. Leaf-blades firm, cordate-ovate, 5–20 mm. long, 5–15 mm. wide, subacuminate to a blunt tip, shallowly serrate with 6–9 teeth on each side, 5–7 nerved, glabrous, or with a few short setae above. Cymes to 7-flowered, the nodes subtended by ovate (lower) to lanceolate (upper) bracts 2–3 mm. long; pedicels 5–15 mm. long, glandular-hirsute. Flowers 5-merous. Hypanthium cup-shaped, 3.4 mm. long, thin-walled, 10-ribbed, glandular-hirsute. Sepals reflexed at anthesis, triangular, subulate-tipped, 2.7 mm. long. Petals elliptic, white, 11 mm. long, 7.5 mm. wide, obtuse, tipped with a stout glandular seta. Stamens dimorphic; episepalous series: filaments slender, 5.2 mm. long; thecae nearly straight, subulate, 3.5 mm. long; connective forming a half-circle, prolonged 2.1 mm. to the filament and bearing a short basal dorsal spur, prolonged below the filament 2 mm. in an unlobed flattened organ; epipetalous series: filaments 5.8 mm. long; anthers erect, straight, linear-subulate, 3.5 mm. long; connective not prolonged. Ovary 3-celled; style declined, 7.5 mm. long; stigma punctiform. Seeds flat, cuneate, 1.7 mm. long, wing-margined around the elliptic embryo.

TYPE: *Cuatrecasas & Arbeláez 6239*, from Cerro de Munchique, western Cordillera, Dept. Cauca, Colombia.

Monochaetum calvescens Gleason, sp. nov. Sect. *Bonplandiae*. A *M. Bonplandii* differt ramis petiolis foliis pedicellis brevissime strigosis non patulo-pubescentibus, hypanthio subduplo majore glabro, sepalis minutissime ciliatis ceterum glabris, appendice staminum minorum elliptica.

Younger stems, petioles, leaf-blades and pedicels short-strigose. Petioles slender, 4–8 mm. long. Blades ovate-oblong, up to 35 by 15 mm., short-acuminate, ciliate with ascending hairs, rounded at base, sub-5-pli-nerved, thinly strigose on both sides, glabrous above over the primary veins. Flowers 4-merous, in small clusters terminating the stem and branches, on strigose pedicels 5–10 mm. long. Hypanthium narrowly campanulate, purple-red, glabrous, about 9 mm. long. Sepals triangular-lanceolate, reflexed at anthesis, 9 mm. long, 3–3.5 mm. wide at base, acuminate, minutely ciliate, with a few short setae at the sinus, otherwise glabrous. Petals red-violet, apparently

about 15 mm. long. Episepalous stamens: filaments flat, thin, 8.4 mm. long; anthers erect or nearly so, linear-subulate, sterile, 2.2–3.1 mm. long; appendage divergent, flattened, narrowly elliptic, 1.2–1.5 mm. long. Epipetalous stamens: filaments stouter, 7.7–8.3 mm. long; anthers deflexed, linear-subulate, slightly arcuate, opening by a dorso-terminal pore, the thecae 9–10 mm. long; connective 0.5 mm. long, channeled on the ventral side; appendage curved forward into a quarter-circle, 2.5 mm. long, the basal half channeled on the concave side, the distal half flattened, widened, and irregularly 3-lobed. Ovary setose at the summit; style slender, 14 mm. long; stigma punctiform.

TYPE: *Arbeláez & Cuatrecasas 6611*, from Fusagasugá, Dept. Cundimarca, Colombia, alt. 2100–2400 m.

The structure of the stamens places the species beside the well-known *M. Bonplandii* (Kunth) Naud., the only other member of the species-group. The very apparent differences between the two are stated in the diagnosis.

Meriania colombiana Gleason, sp. nov. Sect. *Umbellatae*. Frutex scandens; a *M. quintuplinervi* differt dentibus calycis exterioribus sepala multo excedentibus, a *M. boliviensi* foliis subtus densius tomentosis antheris multo longioribus, a *M. Weberbaueri* structura antherarum et connectivi.

Climbing shrub. Pubescence of spreading hairs densely plumose or stellate at the base only. Younger branches obscurely 4-angled, ferruginous-hirsute, more densely so at the nodes, soon glabrescent. Petioles slender, 2–4 cm. long, hirsute. Blades thin, elliptic, 12–20 cm. long, 5.5–9 cm. wide, acute, essentially entire, rounded at base, 5-pli-nerved, above ferruginous-pubescent when young, soon glabrescent, beneath permanently whitened with hairs up to 2 mm. long, the basal branches 0.4 mm. long. Inflorescence 2 dm. long, pubescent like the stem, the flowers in sessile or stalked clusters of 3, the latter usually with a single flower from the base of the stalk; pedicels 15–20 mm. long. Hypanthium campanulate, thick-walled, 8.5 mm. long to the torus, densely ferrugious-pubescent, the hairs curved-ascending. Calyx-tube prolonged 4.5 mm. to acute sinuses; sepals broadly round-ovate, 2 mm. long, short-acuminate; exterior teeth terete, 6 mm. long, surpassing the sepal by 3 mm. Petals triangular-obovate, 23 mm. long, almost as wide, barely retuse, entire. Stamens nearly isomorphic; filaments stout, flattened, glabrous, 8.4–10.3 mm. long, part of them twisted to bring the anthers parallel with each other; anthers subulate, tangentially flattened, about 8.5 and 10 mm. long, opening by a single pore; connective not elevated, prolonged straight back 1–1.4 mm. as a triquetrous organ (large stamens) or as a nearly terete organ channeled on the dorsal side, bearing at base an erect spur, flat, triangular, 0.7 mm. long in the small stamens, conic and 1 mm. long in the large. Ovary superior, 5-celled; style glabrous, slightly sigmoid, 29 mm. long; stigma truncate.

TYPE: *Arbeláez and Cuatrecasas 5285*, from Dintel, Dept. Cundimarca, Colombia, alt. 2300–2700 m.

M. colombiana, *M. quintuplinervis* Naud., *M. boliviensis* Cogn., and *M. Weberbaueri* Cogn. form a group of closely related species characterized by large sepals and the peculiar type of pubescence described above. In the

second the exterior teeth scarcely extend beyond the sepals, in the third the flowers are much smaller and pubescence sparse, and in the last the connective is elevated into a prominent dorsal ridge and not prolonged at base. *M. umbellata* Karst., which was also assigned to this group by Cogniaux, is quite a different plant, more closely related to the well-known *M. speciosa.*

Diolena purpurea Gleason, sp. nov. Herba humilis cauli hirsuto; folia majora lanceolata brevissime petiolata, minora sessilia reniformia; racemus brevis, floribus confertis 5-meris; hypanthium purpureo-hirsutum; stamina dimorpha, antheris oblongis, connectivo setis 2 ornato, in ser. int. gracilibus 0.6 mm. longis, in ser. ext. 2 mm. longis apice clavatis.

A low herb, the stems hirsute with usually reflexed hairs. Larger leaf-blades lanceolate, 6–12 cm. long, 2–3.5 cm. wide, obtusely acuminate, minutely denticulate, long-ciliate, inequilateral at base, 3-pli-nerved, pilose above, especially on the veins, purple and hirsute beneath. Smaller leaves sessile, reniform, up to 1 cm. long. Raceme short, with crowded, 5-merous, short-pediceled flowers. Hypanthium hemispheric, 2.2 mm. long, densely hirsute with purple hairs. Sepals scarious, truncate-triangular, erose-fimbriate, 0.4 mm. long; exterior teeth subulate, erect, 1.5 mm. long. Petals oblong, 6 mm. long, white, subacute. Stamens dimorphic; filaments slender but flat, 2.1 or 1.5 mm. long; anthers semi-ovoid, nearly 1 mm. long, opening by a ventro-terminal pore; connective prolonged at right angles to the thecae, 0.4 or 0.3 mm. long, bearing two anterior appendages 1.9 mm. long and clavate distally or 0.6 mm. long and slender. Style bent laterally near the apex, 3.6 mm. long, thickened above to the truncate stigma.

TYPE: Killip 35243, from dense forest on the upper Río San Juan, Corcovado Region, Intendencia El Chocó, Colombia, alt. 200–275 m.

It is nearest to *D. auriculata* Triana, from which it differs in its strongly hirsute stem, foliage and hypanthium.

Leandra hylophila Gleason, sp. nov. Rami petioli et panicula strigosa; folia breviter petiolata anguste oblonga utrinque angustata 5-pli-nervia supra strigulosa subtus pubescentia; panicula multiflora pyramidalis; hypanthium subglobosum strigosum; calycis lobi breves triangulares quam dentes exteriores duplo breviores; petala anguste oblonga; ovarium glabrum 3-loculare.

Shrub about 5 m. high, the younger branches roundly 4-angled, closely strigose with brown hairs less than 1 mm. long; petioles stout, 1–2 cm. long, strigose like the stem; leaf-blades thin, narrowly obovate-oblong to oblong-lanceolate, up to 20 by 7 cm., acute or short-acuminate, obscurely denticulate and ciliate, acute or cuneate at base, minutely strigose above (hairs 0.5 mm. long), pubescent beneath with hairs up to 1 mm. long. Panicle short-peduncled, 10 cm. long, freely branched, pubescent like the stem. Flowers sessile, 5-merous. Hypanthium subglobose, 1.7 mm. long, sparsely short-strigose. Calyx-tube scarcely developed; sepals membranous, broadly triangular with concave margins, 0.5 mm. long from the torus; exterior teeth stout, erect, subconic, projecting about 0.3 mm. Petals narrowly oblong with inflexed margins and cucullate apex, orange, 1.3 mm. long. Stamens isomorphic; filaments stout, 1–2 mm. long; anthers straight, 1.8 mm. long; con-

nective elevated at its base into a conspicuous dorsal protuberance. Ovary two-thirds inferior, 3-celled, glabrous; style 4 mm. long; stigma capitellate.

TYPE: *Klug 1936*, from forest at Umbria, Comisaria del Putomayo, Colombia, alt. 325 m.

Krukoff 10856, from the vicinity of Mapiri, Bolivia, is identical. Since the genus Leandra has received no careful study and its species are not arranged in logical order, it is impossible to discuss the possible relationship of the new species.

Miconia stellulata Gleason, sp. nov. Sect. *Jucunda*. A *Miconia pubicalyci* differt pubescentia ubique multo tenuiore, foliis 5-pli-nerviis, sepalis fere erectis, petalis calyci styloque glabris, dentibus exterioribus crassis triangularibus.

Tree 8 m. high, the branches terete and glabrous, the youngest twigs, petioles, and inflorescence closely and minutely brown-stellate-tomentose. Petioles slender, 10–15 mm. long, deeply and narrowly channeled above. Blades firm, ovate-lanceolate, up to 14 cm. long and 5.5 cm. wide, long-acuminate, entire, rounded at the base, 5-pli-nerved, the principal laterals arising 5–8 mm. from the base and outwardly curved, lightly impressed above, the straight secondaries 3–5 mm. apart, ascending at an angle of about 70°, obscure above; young leaves brown-stellate-tomentose beneath, sparsely stellate above, soon glabrate on both sides. Panicle small, the 5-merous flowers sessile in small glomerules. Hypanthium obconic, 3.7 mm. long to the torus, very thinly and minutely stellate-pubescent. Calyx soon deciduous, scarcely spreading; calyx-tube prolonged 0.7 mm. to acute sinuses, glabrous; sepals broadly depressed-semicircular, 1 mm. long from the torus, with no free margin; exterior teeth triangular, acute, carinate on the inner side, adnate to the sepal and extending 0.9 mm. beyond it. Petals obovate-oblong, 4.2 mm. long, 2 mm. wide, obliquely retuse, glabrous. Stamens isomorphic but differing slightly in size; filaments slender, glabrous, 4 or 4.5 mm. long; anthers subulate, slightly arcuate, 2-celled, opening by a small terminal pore, 3.4 or 3.9 mm. long, the thecae prolonged briefly below the filament; connective simple. Ovary half inferior, 3-celled, the rounded summit glabrous; style slender, glabrous, 10.3 mm. long; stigma truncate.

TYPE: *Krukoff 11376*, from Copacabana, Dept. La Paz, Bolivia, alt. 850–950 m.

It is a member of the species-group within Sect. *Jucunda* characterized by the extraordinary development of the exterior teeth, discussed by me in 1932.[1] To the eight species then known two have since been added. One of these is obviously similar to *M. stellulata* but differs in the characters stated in the diagnosis.

Miconia rosea Gleason, sp. nov. Sect. *Adenodesma*. Rami juniores, petioli, venae mediae, inflorescentia et hypanthia densissime tomentosi; laminae membranaceae ellipticae petiolatae 5-pli-nerviae supra glabrae subtus ad venas sparse stellatae; sepala bene evoluta; stamina dimorpha; antherae subulatae; connectiva basi dilatata secus margines glandulis ornata.

[1] Bull. Torrey Club **59**: 360–363.

Tree 6–8 m. high, the younger branches densely tomentose with stout conic hairs about 1 mm. long. Petioles stout, 2–5 cm. long, tomentose like the stem. Blades thin, green on both sides, elliptic, 16–26 cm. long, 8–14 cm. wide, abruptly acuminate, repand-denticulate, cordulate at the rounded base, 5-plinerved, glabrous above with obscure plane veins spreading at nearly right angles, very sparsely stellate on the veins beneath. Panicle few-flowered, sparsely branched, 13 cm. long. Flowers 5-merous, sessile but apparently on pedicels 5–8 mm. long. Hypanthium hemispheric, 4.2 mm. long to the torus, very thick-walled, densely tomentose. Calyx-tube flaring, 2.3 mm. long, sparsely sericeous within; sepals broadly triangular from acute sinuses, 3.1 mm. long from the sinus, sericeous within, pubescent outside like the hypanthium; exterior teeth minute inconspicuous thickenings. Petals coriaceous or fleshy, elliptic-oblong, 16 mm. long, 8.5 mm. wide, slightly inequilateral. Small stamens: filaments stout, 7.5 mm. long, finely pubescent; anthers slightly arcuate, subulate, 6.6 mm. long, with convolute thecae; connective widened below and extending over half the sides of the thecae, bearing near its margin 6–10 short-stipitate glands. Large stamens: filaments 9 mm. long, pubescent as before; anthers slightly sigmoid, subulate, 7.5 mm. long, the thecae slightly convolute; connective expanded at base over the whole sides of the thecae and bearing around its margin 12–20 nearly sessile glands. Ovary mostly inferior, 5-celled, with a terminal erect glabrous collar 1 mm. high; style straight, 16 mm. long, finely pubescent; stigma truncate.

TYPE: *Cárdenas 762*, from Chimore, Río San Rafael, Cochabamba, Bolivia, in damp forest, alt. 800 m.

The structure of the anther places the species at once in the section *Adenodesma* and adjacent to *M. axinaeoides* Gl., also from Bolivia. It resembles this species in general habit, except its long petioles, but differs from it in its pubescence, its well-developed sepals, and the shape of the connective. A better knowledge of *M. Urbaniana* Cogn., of southern Peru, may eventually show that it is also related here, although assigned by its author to Sect. *Eumiconia*.

Miconia barbicaulis Gleason, sp. nov. Sect. *Amblyarrhena*. Rami stellato-puberuli et longissime purpureo-setosi; folia longe petiolata subtus purpurea late ovata, breviter acuminata, basi subcordata, 7-nervia, supra hirsutula subtus mox glabra; panicula laxa pauciflora, nodis setosis; flores 5-meri; calyx calyptratus demum in lobos irregulariter ruptus; stamina isomorpha leviter connata; antherae 4-loculares, connectivo basi in lobum dorsalem producto.

Shrub 12 dm. high, the younger stems 4-sulcate, sparsely setose with spreading or deflexed blue hairs up to 12 mm. long. Petioles 5–7 cm. long, pubescent like the branches. Blades thin, broadly ovate, 20–25 cm. long, 15–17 cm. wide, short-acuminate, toothed and ciliate, subcordate, 7-nerved, hirsutulous above, hirsute beneath when young, soon glabrescent. Panicle 12 cm. long, loose, few-flowered, long-setose at the nodes. Flowers 5-merous. Hypanthium subglobose, 2.2 mm. long to the torus, sparsely long-setose. Calyx calyptrate, membranous, 2.6 mm. long, at maturity divided into irregular lobes, sparsely setose; exterior teeth spreading from the middle of the lobes, subterete, 1 mm. long. Petals pale rose, ovate-oblong, 3 mm.

long, 2 mm. wide, obtuse, entire, scarcely inequilateral. Stamens isomorphic, coherent in a ring; filaments broad and flat, 1.4 mm. long; anthers stout, radially flattened, blunt, 1.4 mm. long, 4-celled, opening by a minute terminal pore; connective elevated into a ridge over the thecae and prolonged at base into a flat rhombic dorsal appendage 0.6 mm. long. Ovary wholly inferior, 3-celled; style 3 mm. long; stigma capitellate.

TYPE: *Skutch 4420*, from vicinity of Puyo, Napo-Pastaza, Ecuador, alt. 750–1000 m.

The anthers are distinctly those of the section *Amblyarrhena*, and the same kind of connective occurs in *M. acalephoides* Naud. The only species of the section which it resembles in general appearance are *M. cardiophylla* Cogn., *M. Lechleri* Triana and *M. plumifera* Triana, which have glomerate flowers, unappendaged anthers, and normal calyx. The calyptrate calyx suggests the section *Laceraria*, in which *M. Wagneri* Macbride has a similarly prolonged connective but differs in its anthers, exterior teeth and foliage.

Miconia mapirensis Gleason, sp. nov. Sect. *Amblyarrhena*. Rami dense substrigosi pilis inflexis; folia breviter petiolata elliptica breviter acuminata basi rotundata sub-5-pli-nervia, utrinque brevissime setulosa; inflorescentia paniculata ramosa; floribus 5-meris in glomerulos dense aggregatis; hypanthium hirsutum; sepala rotundata, dentibus exterioribus triangularibus adpressis; filamenta dense glandulosa; antherae 4-loculares incurvae, connectivo simplici; ovarium 4-loculare; stigma late capitatum.

Small tree, 8 m. high. Younger branches terete, densely substrigose with incurved stiff hairs. Petioles 10–15 mm. long, pubescent like the stem. Blades firm, elliptic, 12–16 cm. long, 4.5–6 cm. wide, short-acuminate, entire, rounded at base, sub-5-pli-nerved, setose on both sides, more densely beneath, with hairs like those of the stem; secondary veins about 5 mm. apart, ascending at an angle of about 75°. Panicle short-peduncled, 10–12 cm. long, freely branched, the axis and spreading branches densely substrigose. Flowers 5-merous, densely aggregated into terminal glomerules, on pedicels 1–1.5 mm. long, subtended by linear orange-red bracts 2 mm. long. Hypanthium short-cylindric, 2.8 mm. long to the torus, densely hirsute. Sepals broadly rounded, 1.5 mm. long from the torus; exterior teeth triangular, appressed, rather fleshy, half as long as the sepals, mostly adnate. Petals broadly elliptic, 2.8 mm. long, broadly retuse. Stamens isomorphic; filaments stout, flattened, 2.6 mm. long, densely stipitate-glandular; anthers stout, incurved, 2.6 mm. long, 4-celled; connective simple. Ovary two-fifths inferior, 3-celled, the free summit conic, sharply 10-ribbed, extended as 10 connate lobes surrounding the style; style stout, villosulous, 6.5 mm. long; stigma depressed-capitate, 1.7 mm. wide.

TYPE: *Krukoff 11215*, from Copacabana, Dept. La Paz, Bolivia, alt. 850–950 m. Another sheet from the same locality is *Krukoff 11188*.

Miconia mapirensis is a member of a small group of Andean species characterized by glandular filaments, incurved anthers, broad stigmas, and glomerate flowers and including *M. modica* Gl. and *M. lasiostyla* Gl. with stellate pubescence, *M. amabilis* Cogn. with nearly glabrous stem and stellate-

pubescent hypanthium, and *M. Bangii* Cogn., which is nearly or quite glabrous throughout. In all of these the inner pair of veins leave the midvein at an acute angle, while the outer pair are curved into the perimeter of an ellipse. *M. sanguinea* Triana also shares these characters except as to inflorescence; its flowers are long-pedicelled.

Miconia megastigma Gleason, sp. nov. Sect. *Amblyarrhena*. Rami hirsuti et stellati; folia breviter petiolata, ovato-oblonga, breviter acuminata, basi rotundata vel subcordata, 5-pli-nervia, primo utrinque pubescentia mox glabra; panicula pauciramosa; flores 5-meri; hypanthium stellatum et setosum; sepala late triangularia; petala late ovata; stamina paulo dimorpha; filamenta lata glandulosa; antherae obovoideae, connectivo ser. ext. in appendicem dorsalem producto; stylus glandulosus; stigma latum peltatum.

Slender vine climbing by roots, the younger stems terete, hirsute (hairs 1.5–2 mm. long) and minutely stellate. Petioles about 1 cm. long, pubescent like the stem but more densely. Blades oblong, up to 10 cm. long by 6 cm. wide, short-acuminate, entire or nearly so, ciliate at least when young, rounded or subcordate at base, 5-pli-nerved, minutely stellate above when young, soon glabrous, paler and glabrous beneath. Panicle about 1 dm. long, pubescent like the stem, its few branches spreading at right angles. Flowers 5-merous. Hypanthium hemispheric, 2 mm. long, nearly 4 mm. wide, minutely stellate and sparsely long-setose. Calyx-tube not prolonged; sepals horizontally spreading, broadly triangular, nearly 1 mm. long, more than 2 mm. wide; exterior teeth stoutly subulate, appressed, exceeding the sepals. Petals white, thick and fleshy, broadly ovate, 4 mm. long, essentially symmetrical. Episepalous stamens: filaments 1.8 mm. long, 1.3 mm. wide, sparsely glandular on the margin; anthers obovoid, 2.1 mm. long, 4-celled; connective expanded at base into a transversely elliptic fleshy dorsal lobe 0.6 mm. long, 1.3 mm. wide. Epipetalous stamens: filaments as before, but slightly narrower, densely glandular on the back only; anthers as before; connective scarcely prolonged, truncate. Ovary nearly inferior, 5-celled; style 4 mm. long, densely glandular; stigma peltate, 5-lobed, 2.4 mm. wide.

TYPE: *Skutch 4558*, from vicinity of Puyo, prov. Napo-Pastazo, Ecuador, alt. 750–1000 m.

The species is undoubtedly related to *M. Killipii* Gl., to which it bears a strong superficial resemblance. The latter is a tall shrub with circular stigma and unappendaged isomorphic anthers.

Miconia Skutchii Gleason, sp. nov. Sect. *Amblyarrhena*. Rami dense tomentosi sub setis aureis longis; folia longe petiolata cordato-ovata, usque 22 cm. longa 16 cm. lata, acuminata, dentata, 9-nervia, supra setosa subtus molliter pubescentia. Panicula gracilis; flores 5-meri; hypanthium dense villosum; sepala semicircularia hyalina; stamina isomorpha, connectivo infra thecas breviter producto late dilatato.

Shrub 7 dm. high, the younger branches deeply 4-sulcate, densely tomentose with minute pale hairs, densely hirsute with golden bristles to 2 mm. long. Petioles stout, pubescent like the stem, nearly half as long as the blades. Leaf-blades minutely puberulent above and setose with golden hairs to 2 mm.

long, beneath softly pubescent with very slender hairs 0.3 mm. long. Panicle slender, 15 cm. long, the lower branches 2 cm. long. Flowers nearly sessile, glomerate, 5-merous. Hypanthium 3.7 mm. long to the torus, very densely lanate with spreading hairs to 1.5 mm. long. Calyx erect, the tube prolonged 0.7 mm., pubescent like the hypanthium; sepals semicircular, hyaline, 1.4 mm. long from the torus, minutely erose-ciliate; exterior teeth wholly adnate, projecting 0.6 mm. Petals oblong, 5.5 by 2.8 mm., white, essentially symmetrical. Stamens isomorphic; filaments slender, 2.5 mm. long, obscurely geniculate near the summit; anthers oblong, 2.1 mm. long, 4-celled; connective thickened and widened toward the base, prolonged 0.6 mm. below the thecae into a thick, obscurely 3-lobed appendage. Ovary nearly inferior, 5-celled, glabrous; style straight, 6 mm. long; stigma punctiform.

TYPE: *Skutch 4519*, from vicinity of Puyo, prov. Napo-Pastaza, Ecuador, alt. 750–1000 m.

Comparatively few other species of this section of *Miconia* have cordate leaves, and in none of them is the pubescence so dense. It varies in our plant from extremely delicate hairs only 0.2 mm. long through all intermediate stages to fairly stiff bristles 2 mm. long, producing a golden indument over the stem, petioles, panicle and hypanthium.

Miconia chrysocoma Gleason, sp. nov. Sect. *Cremanium*. Frutex, ramis hirsutis; folia inter minores, flavo-viridia, oblonga vel oblongo-lanceolata, argute denticulata, saepe ciliata, 5-pli-nervia, subtus ad venas villosa; panicula aureo-hirsuta; flores breviter pedicellati glomerati; hypanthium aureo-villosum; stamina isomorpha, connectivo basi breviter 3-lobo; stigma obconicum.

About a meter high; upper branches densely brown-hirsute with stoutish, rather flexuous, spreading hairs 1–2.5 mm. long, beneath the hairs somewhat pulverulent. Petioles stout, hirsute like the stem, 10–15 mm. long. Blades firm, yellow-green, oblong-lanceolate or oblong, up to 9 by 3 cm., subacuminate, sharply denticulate with shallow upcurved teeth alternating with single cilia, rounded at the base, 5-pli-nerved, the outer pair submarginal, glabrous above, villous beneath on the primaries, less so on the secondaries and nearly glabrous on the surface. Panicle nearly sessile, about 10 cm. long, hirsute with yellow hairs; pedicels 1 mm. long. Flowers glomerate, 5-merous. Hypanthium subglobose, 2 mm. long to the sinus, loosely villous. Calyx-lobes nearly semicircular from acute sinuses, 0.4–0.5 mm. long, very thin; exterior teeth equal in width but half as long, slightly spreading. Petals broadly elliptic, retuse, white, 1.8 mm. long. Stamens isomorphic; filaments 2.2 mm. long; anthers 1.2 mm. long, opening by two wide terminal pores, the connective prolonged below into a dorsal and two ventral lobes 0.2–0.3 mm. long.

TYPE: *Killip & Smith 18035*, from La Baja, Dept. Santander, Colombia, alt. 2700–3500 m.; *Cuatrecasas 1149* and *1742*, from Boyaca, are the same.

Through the artificial key in Cogniaux' monograph, our species appears to be related to *Miconia divergens* Triana, a larger plant with much larger entire leaves and capitate stigma.

Clidemia Killipii Gleason, sp. nov. Sect. *Calophysa*. Rami glandulosohirsuti; petioli formicario hirsuto tecti; laminae magnae falcatae breviter

acuminatae, basi oblique cordulatae; flores 5-meri; hypanthium glandulosum; sepala rotundato-triangularia, dentibus exterioribus toto adnatis subulatis, sepala breviter excedentibus; antherae anguste subulatae inappendiculatae; ovarium corona ornatum.

Shrub about a meter high, the upper branches densely glandular, the hairs to 2.5 mm. long, flattened at the base. Petioles 1 cm. long or less, the lower side completely covered by a sparsely hirsute convolute formicarium. Blades oblong-elliptic or oblong-obovate, essentially isomorphic, to 23 cm. long by 12 cm. wide, abruptly short-acuminate, irregularly denticulate, obliquely cordulate at base, 3-pli-nerved with an additional marginal pair, hirsute above, hirsute on the veins beneath, the hairs partly glandular. Panicles axillary, slender, glandular-hirsute, 14–18 cm. long, the lateral branches 1–2 cm. long. Flowers 5-merous, short-pedicelled. Hypanthium tubular-urceolate, dilated at the base, 3.8 mm. long to the torus, glandular-hirsute, the hairs to 1.7 mm. long. Calyx-tube nearly erect, 0.7 mm. long. Sepals rounded-triangular, 1–1.1 mm. long from the torus, obtuse; exterior teeth glandular like the hypanthium, stoutly subulate, adnate to the end of the sepal, projecting about 0.6 mm. Petals light green, oblong-elliptic, 5.2 mm. long, retuse, slightly inequilateral. Stamens essentially isomorphic; filaments slender, 5.2 mm. long; anthers subulate, 5.3 mm. long, opening by a ventro-terminal (outer series) or dorso-terminal (inner series) pore. Ovary 5-celled, half-inferior, the rounded glabrous summit prolonged into a terete crown 0.4 mm. high; style nearly straight, 4.3 mm. long; stigma punctiform.

TYPE: *Killip 35249,* from dense forest on a ridge along the Yeraciií Valley, Corcovada Region, Intendencia El Chocó, Colombia, alt. 200–275 m.

While definitely related to *C. juruensis* (Pilger) Gl., *C. foliosa* Gl. and *C. heterophylla* (Desr.) Gl. (cf. Bull. Torrey Club **58**: 79–85. 1931), our species is distinguished from each of them by exceptionally strong characters. All three have sessile or very short flower-clusters; in the second and third the leaves are dimorphic; in the first the ovary is setose, and several other less conspicuous but equally important characters distinguish them from *C. Killipii.*

Clidemia Pittieri Gleason, sp. nov. Sect. *Calophysoides.* Habitu *Clidemiae gracilis* Pitt. similis et illa forsan affinis, differt caulibus teretibus, foliis amplexicaulibus, antheris late dolabriformibus 4-locularibus.

Small tree to 8 m. tall (according to Woodson), with terete twigs, glabrous throughout. Leaves sessile, cordate-clasping, abruptly acuminate, otherwise strongly dimorphic, the larger ovate-lanceolate, 8–15 cm. long, 3–7 cm. wide, 5-nerved with an additional weak marginal pair, the smaller broadly ovate to rotund, 2–3 cm. long and nearly or quite as wide. Cymes from the axils of the upper large leaves, few-flowered, 3–6 cm. long, pedunculate, trichotomous, the very slender branches subtended by linear bracts 6–2 mm. long. Flowers 5-merous, Hypanthium subglobose, fleshy, reddish, 3.3 mm. long to the torus. Calyx-tube fleshy, somewhat flaring, prolonged about 0.4 mm. to very broad sinuses; sepals broadly depressed-triangular, about 0.6 mm. long; exterior teeth adnate for about half their length, resembling the sepals in shape but smaller. Petals red, subrotund, 4 mm. long and wide, inequilateral, shallowly retuse, 9-nerved. Stamens isomorphic; filaments

stout, nearly 2 mm. long; anthers stout, 1.3 mm. long and nearly as wide, 4-celled; connective elevated in the lower half into a prominent dorsal ridge, unappendaged. Ovary three-fourths inferior, 5-celled, its summit truncate-conic; style stout, 4.5–5 mm. long; stigma truncate.

TYPE: *Pittier 3177*, from Prov. Chiriqui, Panama, alt. about 1700 m.; also collected more recently in the same province by *Woodson & Schery, 289* and *562*.

This remarkable plant has been known to me for several years and has been left undescribed because its anthers are so unlike those of the other species of *Clidemia*. In all other features it agrees with that genus. It is distinguished from *C. gracilis* Pitt. at a glance by its cordate-clasping leaves.

Ossaea spicata Gleason, sp. nov. Sect. *Bractearia*. Frutex ramis tomentosulis; laminae breviter petiolatae oblanceolatae caudato-acuminatae 3-nerviae, supra glabrae subtus ad venas subtomentosae; flores sessiles in glomerulis spicatis, bracteati; hypanthium subtomentosum; sepala scariosa dentibus exterioribus vix evolutis; petala dorso lepidoto-stellata; antherae basi in calcar breve productae.

Shrub 3–4 m. high, the younger branches slender, thinly tomentose. Petioles 5–10 mm. long, pubescent like the stem and setose toward the base on the upper side. Blades thin, oblanceolate, paler beneath, 12–18 cm. long, 4–6 cm. wide, caudate-acuminate (acumen linear, obtuse, 10–15 mm. long), repand-denticulate, narrowed from above the middle to an acute base, 3-nerved, with an additional pair of submarginal veins, glabrous above, thinly subtomentose beneath on the primary veins only. Flowers 5-merous, sessile in small glomerules subtended by oblong to ovate bracts 1–1.5 mm. long, separated by internodes 10–15 mm. long, forming a straight, axillary or terminal, interrupted spike. Hypanthium cup-shape, 1.6 mm. long to the torus, thick-walled, subtomentose. Calyx-tube nearly erect, 0.5 mm. long; sepals very thin, broadly ovate to triangular, 1.2 mm. long from the torus; exterior teeth minute thickened triangles. Petals erect, lanceolate, 4.4 mm. long, lepidote-stellate on the back, the minute subulate exterior teeth erect, the actual apex cucullate and minutely inflexed. Anthers linear, 1.4 mm. long; connective prolonged at base into a lanceolate, erose, dorsal lobe about 0.4 mm. long. Ovary 3-celled, glabrous; style straight, glabrous; stigma apparently punctiform.

TYPE: *Killip 35166*, collected in dense forest between Quebrada Guarapo and Mandinga, Intendencia El Chocó, Colombia, alt. 120–180 m.

In its spicate bracted inflorescence *O. spicata* is clearly related to *O. rufibarbis* Triana, which is a much more robust plant, with pli-nerved leaves, long-hirsute inflorescence, and much larger bracts.

THE NEW YORK BOTANICAL GARDEN,
NEW YORK, NEW YORK

THREE NEW SPECIES OF MEXICAN UMBELLIFERAE

MILDRED E. MATHIAS AND LINCOLN CONSTANCE

Arracacia ternata Mathias & Constance, sp. nov. Herba gracilis caulescens e radice horizontali crassa ramosa, 6–10 dm. alta, omnino glabra vel minute scaberula; folia in ambitu deltoidea, 1.5–3 dm. longa, 3–4-ternata, foliolis ovato-lanceolatis apice acutis, basi cuneatis, terminalibus exceptis distinctis petiolulatis sessilibusve, 2–5 cm. longis, 1–2 cm. latis, crasse dentatis lobatisque, dentibus triangularibus mucronatis; petioli gracillimi, 5–15 cm. longi, basi vaginantes; folia caulina pauca foliis basilaribus similia, insuper demum multo reductis uni- vel plurilobatis, lobis elongatis filiformibus, 1–2 cm. longis, vaginis obsoletis; inflorescentia ramosa pedunculis infimis alternis, superioribus verticellatis gracilibus patenti-adscendentibus subaequalibus, 2–3.5 cm. longis; radii fertiles 5–6 graciles patenti-adscendentes subaequales, 2–3.5 cm. longi; pedicelli fertiles 1–5, graciles patenti-adscendentes, 3–6 mm. longi; flores purpurei, petalis ovalibus; stylopodium breviconicum, disco conspicuo crenulato, stylis brevibus divergentibus recurvatisve; carpophorum usque ad basim bifidum; fructus oblongus, 7–12 mm. longus, 2–3 mm. latus, glaber, apice basique attenuatus, apice emarginatus, costis filiformibus; vittae parvae in intervallis 1–2, in commissuris 4; seminis facies profunde sulcata.

Slender caulescent, branching perennial from a stout, horizontal woody root, 6–10 dm. high, glabrous throughout or the foliage minutely scaberulous; leaves deltoid in general outline, excluding the petioles 1.5–3 dm. long, 3–4-ternate, the leaflets ovate-lanceolate, 2–5 cm. long, 1–2 cm. broad, acute at apex, cuneate at base, all but the terminal distinct, coarsely toothed and lobed with triangular-mucronate teeth, petiolulate or sessile; petioles very slender, 5–15 cm. long, sheathing at base; cauline leaves few, like the basal, the uppermost greatly reduced and consisting of 1–several elongate, filiform lobes 1–2 cm. long, the sheaths obsolete; inflorescence freely branched, the lower peduncles alternate, the upper verticillate, slender, 3–6 cm. long, often with a small sterile lateral umbel; involucre wanting, or of a solitary foliaceous linear bract; involucel of 1–several linear bractlets, 3–5 mm. long, exceeding the flowers; fertile rays 5–6, slender, spreading-ascending, subequal, 2–3.5 cm. long; fertile pedicels 1–5, slender, spreading-ascending, 3–6 mm. long; flowers purple, the petals oval; stylopodium low-conical, with a conspicuous crenulated disk, the styles short, divergent or recurved; carpophore 2-cleft to the base; fruit oblong, 7–12 mm. long, 2–3 mm. broad, glabrous, tapering at each end, and with a V-shaped notch at the apex, the ribs filiform; oil tubes small, 1–2 in the intervals, 4 on the commissure; seed face deeply sulcate.

Type specimen: Bartlett 10294, Cerro Parrena, vicinity of San José, Sierra de San Carlos, Tamaulipas, Mexico, alt. 3100 ft., July 13, 1930 (MBG[1] TYPE, US).

This species is known only from the type collection. It is most closely related to *Arracacia fruticosa* and *A. Pringlei*. *Arracacia fruticosa* is a

[1] The institutions in which these specimens are deposited are designated as follows: Royal Botanic Gardens, Kew, K; Missouri Botanical Garden, MBG; New York Botanical Garden, NY; United States National Herbarium, US.

woody species and *A. Pringlei* is characterized by mostly alternate peduncles, longer involucel bracts, more numerous rays, shorter pedicels and white or cream-colored flowers.

Donnellsmithia Hintonii Mathias & Constance, sp. nov. Herba annua vel biennis, 6–12 dm. alta, e radice simplice gracile, foliis nodisque paullo scaberulis; folia in ambitu deltoidea, 6–12 cm. longa, ternato-pinnate dissecta, segmentis terminalibus plerumque distinctis, foliolis lanceolatis ovatisve, 10–30 mm. longis, 5–15 mm. latis, basi cuneatis, pinnatifidis dentatisque lobulis (dentibus) integris, apiculatis glabratis venis rachibusque minute scaberulis; petioli 5–15 cm. longi; folia caulina summa alterna decussatave; umbellae crebro sessiles vel plerumque pedunculatae, pedunculis alternis, 0.5–3 cm. longis; involucrum nullum vel unibracteatum; involucellum nullum; radii 3–6, subaequales, 0.6–1.2 cm. longi; pedicelli fertiles 1–4, 2–6 mm. longi, sterilibus longiores; flores flavi; stylopodium manifestum breve; fructus orbicularis obcordatusve, 1.5 mm. longus, 1.5–2 mm. latus; basi cordatus ad apicem versus attenuatus glaber, apice rotundo, costis filformibus indistinctis; vittae commissurarum ut eae in intervallis 2–4; seminis facies vadose sulcata.

Annual or biennial from a slender taproot, 6–12 dm. high, the foliage and nodes slightly scaberulous; leaves deltoid in general outline, excluding the petioles 6–12 cm. long, ternate-pinnately dissected, the leaflets lanceolate to ovate, 10–30 mm. long, 5–15 mm. broad, mostly distinct, attenuate at apex, cuneate at base, pinnatifid and toothed with entire, apiculate lobes or teeth, minutely scaberulous on the veins and the rachis or glabrate; petioles 5–15 cm. long; uppermost cauline leaves alternate or opposite; peduncles alternate, 0.5–3 cm. long, or some umbels frequently sessile; involucre wanting, or of a single bract; involucel wanting; rays 3–6, subequal, 0.6–1.2 cm. long; fertile pedicels 1–4, 2–6 mm. long, longer than the sterile pedicels; flowers yellow; stylopodium low but evident; fruit orbicular to obcordate, 1.5 mm. long, 1.5–2 mm. broad, cordate at base, rounded but tapering toward apex, glabrous, the ribs filiform, indistinct; oil tubes 2–4 in the intervals and on the commissure; seed face shallowly sulcate.

Type specimen: Hinton 8463, oak woods, Salitre, District of Temascaltepec, State of Mexico, September 19, 1935. (NY TYPE, K).

Specimens examined: MEXICO: llano, Tenayac, 1650 m., *Hinton 4851* (K, NY); barranca, Tenayac, *Hinton 8367* (K, NY); hill, Mina de Agua, 1990 m., *Hinton 2329* (K, NY); Puerto Salitre, 1300 m., *Hinton 1795* (K).

This species is separated from *Donnellsmithia mexicana* by its shallowly sulcate seed face, the fertile pedicels much longer than the sterile, and the pinnatifid and toothed leaflets. Both *D. Hintonii* and *D. mexicana* are readily separable from *D. biennis* by the evident stylopodium, oil tubes several in the intervals, fruit tapering at the apex, and the indistinct ribs.

Prionosciadium simplex Mathias & Constance, sp. nov. Herba perennis caulescens erecta, 8 dm. alta, usque ad inflorescentiam scaberulam omnino glauca glabraque, folia basilaria in ambitu deltoidea, 8–15 cm. longa, biternata, foliolis glabris distinctis petiolulatis subtus glaucis, 1.5–2.5 cm. longis, 0.8–1.5 cm. latis, oblongis ovato-lanceolatisve serrulatis, obtusis vel apice

abrupte acutis, basi truncatis lobis duobus lateralibus instructis; petioli graciles, 3–5 cm. longi, vaginis elongatis oblongis marginibus scariosis; folia caulina foliis basilaribus similia alterna sursum reducta, vaginis conspicuis oblongis; inflorescentiae umbella unica terminalis, interdum ramis lateralibus instructis; pedunculus gracilis, 10–12 cm. longus; involucrum nullum; involucelli bracteolae plures lanceolatae ovato-lanceolataeve acuminatae purpurascentes scaberulae, 3–6 mm. longae; petala purpurea obovata, circa 2 mm. longa; stylopodium depressum, stylis longiusculis; fructus immaturus oblongus basi rotundus, apice truncatus, 6–8 mm. longus, 3–3.5 mm. latus, glaber, dorsaliter valide compressus, costis dorsalibus filiformibus, lateralibus tenui-alatis, alis corpore angustioribus.

Rather slender, caulescent, erect perennial, 8 dm. high, glaucous and glabrous throughout except for the scaberulous inflorescence; basal leaves deltoid in general outline, excluding the petiole 8–15 cm. long, biternate, the leaflets oblong to ovate-lanceolate, distinct, 1.5–2.5 cm. long, 0.8–1.5 cm. broad, obtuse or abruptly acute at apex, truncate at base, finely serrate and often with two lateral lobes at base, glaucous beneath, petiolulate; petioles slender, 3–5 cm. long, the sheaths elongate, oblong with a scarious margin; cauline leaves like the basal, alternate, reduced upwards with a conspicuous oblong sheath; inflorescence of a single terminal umbel or with some lateral branches below; peduncle slender, 10–12 cm. long; involucre wanting; involucel of several lanceolate or ovate-lanceolate, acuminate, purplish bractlets, 3–6 mm. long, shorter than the fruit; fertile rays about 10, spreading-ascending, unequal, 1.5–4.5 cm. long; fertile pedicels 2–6, spreading-ascending, 2–4 mm. long; calyx teeth obsolete; petals purple, obovate, with an inflexed tip, about 2 mm. long; stylopodium depressed, the styles rather long; ovaries glabrous; immature fruit oblong, 6–8 mm. long, 3–3.5 mm. broad, rounded at base, truncate at apex, glabrous, strongly flattened dorsally, the dorsal ribs filiform, wingless, the laterals thin-winged, the wings (in young fruit) narrower than the body.

Type specimen: Nelson 4478, on mountains near Miquihuana, Tamaulipas, Mexico, alt. 7000–9000 ft., June 10, 1898 (US 332,526 TYPE).

Prionosciadium simplex is most nearly allied to *P. humile*, which is itself anomalous in the genus. Both species are characterized by their low slender stature and comparatively simple inflorescence. *Prionosciadium simplex* may be separated from *P. humile* by the finely serrate, oblong to ovate-lanceolate leaflets, 1.5–2.5 cm. long, 0.8–1.5 cm. broad, and the purple flowers.

UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA

INDEX TO AMERICAN BOTANICAL LITERATURE

The aim of this Index is to include all current botanical literature written by Americans, published in America, or based upon American material; the word America being used in the broadest sense.

Papers that relate exclusively to bacteriology, forestry, agriculture, horticulture, manufactured products of vegetable origin, or laboratory methods are not included. If users of the Index will call the attention of the editor to errors or omissions, their kindness will be appreciated.

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